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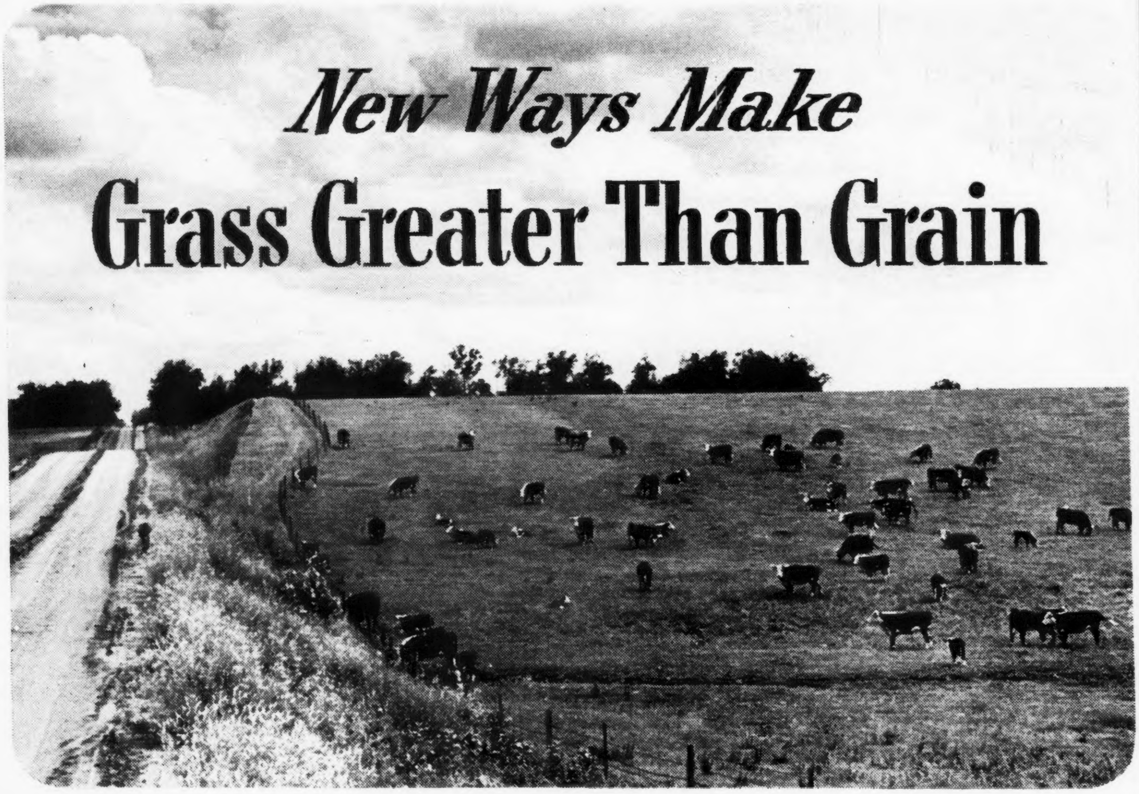
New Ways Make

Grass Greater Than Grain



Grass now grows more feed per acre, produces more meat and milk, brings forth more wealth than the same land will yield with grain. Henceforth grass shall no more be a poor relation in the farming system, but the ace of all crops. Grassland farming means rotations not built around wheat or corn, but around grass . . . grass not merely for rough, thin land, but the richest and most level fields.

Grass grown on fertile soils rich in available nitrogen, if grazed or cut when a few inches high, actually contains as much protein as green legumes. This is doubly important in times when protein concentrates may be scarce and high-priced. In a few weeks it is ready to graze or mow again.

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The experiment stations in your own and near-by states have developed and proved methods for grass growing and pasture improvement. By bulletins and through the extension services they will gladly help you to choose the methods best suited to your farm. Likewise your Case dealer stands ready to help you apply these methods with the machines you already have or may hire from neighbors. Use his service also to keep your machinery working like new and prolong its life. J. I. Case Co., Racine, Wis.

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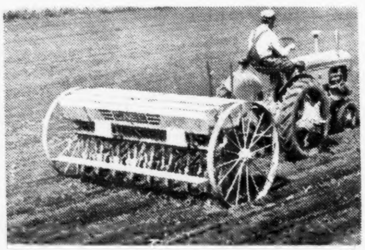

With the eager, easily-handled power of a Case tractor, it is easy to put plenty of grass in your rotation. With tandem hitch of roller-packer and Case Seedmeter drill, fitted with grass seed and fertilizer attachments, you can crush clods, firm the seedbed, fertilize and sow accurately both the small amount of grass or legume seed and its nurse crop of grain.

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As a service to agriculture, this message is appearing in farm papers. It is one of a series urging farmers to adopt advanced practices, using equipment they already have to promote war-time food production and conserve agricultural resources. J. I. Case Co., Racine, Wis.

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AGRICULTURAL ENGINEERING

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Vol. 24, No. 10

EDITORIAL

Let's Look at Costs

HOWEVER effective or otherwise it may be in attaining its avowed objectives, the policy of imposing price ceilings with little or no control of concomitant costs is proving itself a creator of shortages. We see this more especially in the realms of food and of liquid fuels, with both of which agricultural engineering is directly concerned—in the one as producer, in the other as consumer.

To impose an uneconomic price ceiling on milk would produce no perceptible effect on production for weeks and perhaps for months. Farmers would not hoot their cows next morning, nor send them to slaughter next month. But cows have a way of going dry eventually, and it is only by having cows come in fresh from time to time that milk production can be maintained. If the ratio of price to costs promises to be uneconomic, farmers will omit the prerequisites of freshening. It would take a year for effects to be felt by the statistician, and at least another year for the trend to be reversed and a start made toward undoing the damage.

Something like this seems to have occurred in petroleum production, wherein the well is a unit comparable to the cow. Producing wells have continued with only their inherent and inevitable diminution of flow, but the number of wells coming in fresh has been smaller and smaller. After many months the discouragement of drilling has brought us to the point where petroleum production is lower than it could and should be. No doubt it would take equally long before new wells could come fresh in numbers sufficient to reverse the trend.

Probably this obvious principle of economics is being demonstrated in countless other commodities with which we are not so closely concerned but which all play their part in America's waging of its war and sustenance of its people. To hasten victory in a war of production, we should stop discouraging and start encouraging production.

Food Should Cost More

NOT for the sake of agriculture, but for the sake of America, the costs of food should go up, and those costs should be paid by the people who eat it, not by federal taxpayers either present or future. No one can proclaim this principle with such good grace as the agricultural engineer, because no one has so good a record of having multiplied the production and having reduced the production cost of food for years past.

For agriculture it would be a misfortune to build up a fictitious and temporary structure of high prices at a time when farm income already is far higher than it ever has been. It would merely increase the height from which prices must fall and aggravate the postwar problems of adjustment. It would provide a false basis for standards of living from which retrenchment would be painful. Perhaps worst of all, it would dull the desire to enhance income by economy and volume of farm production.

But if they are sound and sincere who argue that our principal peril in the problem of inflation is the so-called inflationary gap, then the best weapon against that peril is to make the necessities of life cost enough to absorb the nation's surplus income. Since food is the prime necessity, it should be the prime means of such absorption.

Moderately higher prices should also ease the pressure on our supplies of food. Certainly the per capita purchase of foods, particularly the luxury foods, advanced in step with industrial incomes. Desirable though that is in normal times, it is distinctly out of order now. Prices high enough to check waste, even to arouse resentment, would help hold purchases down to the level of legitimate hunger.

Obviously such higher prices for food would present a problem for the forgotten families on fixed incomes, those neither in agriculture nor industry. Though they have made no organized outcry, it is they and they alone who can make any logical claim for subsidy of the consumer. Even they should not be spared too much; they should pay enough extra to carry their fair share of the currently borne cost of the war.

Demands for low food prices or consumer subsidies come with worst grace from those workers whose weekly earnings have doubled or trebled, the real war profiteers. To make such demands when food costs have dropped to the lowest levels in human history, expressed as percentage of income even after war taxes are deducted, is more than disregard of the patriotic plea for equality of sacrifice, it shows not even a sense of humor.

It is psychologically unsound and unfair to the consumer to furnish him food for less than it costs to produce. From the production angle also it is psychologically unsound. Farmers properly distrust a price structure with a foundation no firmer than a resolution of Congress, or worse yet, an edict of a bureaucratic agency which may prove as ephemeral as the morning mist. If we are to persuade farmers to take the risks of increased production at increased cost, it must be by firm commitment that prices, whatever they may be, are paid by the people who eat.

Racial Relations

FROM the conduct of cattle and horses in ample pasture we learn that unlike species live peaceably side by side as long as each is allowed to congregate with its own kind, free from intimate intrusion by the other and unprovoked by acute competition for food or shelter. Forcing them together in a crowded corral is inviting trouble.

The long experience of agriculture affords similar lessons as to the relations of unlike races or estates of mankind. On ranches and plantations members of diverse races live and work side by side with little or no friction, not by attempting to disregard racial entities, but by recognizing and respecting them. Harmony and cooperation on farm and in community are possible so long as there is a symbolic separation which each race respects. It may be assignment of distinctive types of work, defined areas of activity, or indeed almost any expedient which avoids direct personal competition or forced intimacy of association.

We do not presume to offer a psychological explanation for the causes of friction among races, though we suspect that they spring from some deep instinct implanted by Nature as an aid to the preservation of racial purity. Rather we offer these observations, empirical though they be, for what they may be worth to other and younger industries, and to other younger, non-rural communities. We commend them also to those of our own profession who, in the impending changes in agriculture, may encounter for the first time the need for racial harmony.

Drainage as an Aid to Increased Food Production

By John G. Sutton

MEMBER A.S.A.E.

WITH the war well into its second year the country is becoming more conscious of its food problem. Last year well-designed posters told us of the importance of food production, but the corner grocery still had an abundant supply of foods. This year shortages of meat, potatoes, butter, eggs, and everyday foods have brought home to us in a forceful manner that abundant food production is one of the first essentials of victory.

This year more emphasis, as well as more and more of the country's resources, is being placed on food production. We have seen land armies organized, farm labor exempted from draft, farm machinery quotas increased, and other measures designed to increase food production. Not only must there be adequate equipment and labor and seed available to plant, cultivate, and harvest the crops, but of equal importance are the soil improvement, conservation, and water management measures which are necessary to insure a high yied per acre. In this country we have great variations in the yields of the common crops. Many crops under good conditions will produce three to four times the yield that crops under less favorable conditions produce. These differences are due largely to differences in soil fertility and moisture conditions and these conditions can be improved by proper soil and water management practices.

The agricultural engineers have many responsibilities to aid in winning the war. However, none seem more important than seeking out, studying, and applying methods of increasing food production. We should study ways and work with other technicians in agriculture to increase the efficiency of production so that less expenditure of man and equipment hours is necessary to produce a unit of crop. Mr. William E. Meek, the able chairman of the Soil and Water Conservation Division of A.S.A.E. in asking me to give this paper stated that drainage has not had the emphasis it deserves. Since about 1921, emphasis has generally been on ways to control production and dispose of surplus crops. Only in the last year or two have we fully realized that we must reverse this trend of two decades and that we must now produce food to the limit. The American Society of Agricultural Engineers should recognize the importance of drainage as one of the important ways of accomplishing increased food production. We must avoid the mistakes of the last war when land was plowed that should never have been plowed and dust bowl conditions and excessive soil erosion resulted.

As we came to Lafayette within the last few days, I am sure that we recognized some of the effects of poor drainage. The heavy rains have delayed the planting of corn and soybeans on most of the land in this vicinity, and especially in Illinois. The damage has been particularly severe on the poorly drained lands. On many poorly drained fields, and especially on the low areas where drainage is not adequate, the crop damage will be great this year, in some cases resulting in complete failure. Most of these poorly drained areas are due to a ditch or tile drain filling with silt and not functioning properly; and they are typical of a very large area of land in the United States.

To attempt to make an appraisal of the effect of drainage improvement on crop production is a difficult task. Improved drainage should go hand in hand with improved crop rotations and other practices resulting in improved soil fertility. Although the well-drained lands will produce considerably higher crop yields, it is not strictly accurate to claim that all of the increased production is due to drainage.

However, it is evident that drainage is a first step in the soil and moisture improvement in getting increased production on the wet lands. The Soil Conservation Service has this year undertaken a considerable number of drainage projects with the object of making a contribution to the war effort through drainage improvements that would not otherwise be undertaken; and at the same time to create a considerable number of demonstrations of proper drainage practices that would lay a sound foundation for an expanded program for the future and encourage farmers to undertake more of the work.

A careful analysis has been made of 35 drainage projects, planned or constructed by the Soil Conservation Service and located in 12 states. There were 450 farms benefited by these jobs. In order to secure an idea of the benefits from this work, the local SCS representative prepared a special estimate of the acreage and yields of the various crops before the drainage work was installed and the anticipated acreages and yields after the work has been completed. This representative was familiar with the farms improved in the areas and the trends to increase acreages of war crops were consistent throughout the jobs. A knowledge of crop yields that well-drained soils in the local areas would produce was the basis for the estimates of the crop yields following drainage. While no great degree of accuracy can be claimed for estimates of this type, field examination of typical projects has convinced the author that the estimates they arrived at are reasonable and that substantial increases in production due to increases in acreages and increases in yield are being secured through this program. The tabulation on page 328 shows the estimated acreages, yields, and value of increased production shown by the various crops for the 35 typical jobs selected. The acreage benefited by all the jobs is 33,992 acres, which is slightly less than the acreage in crops after drainage, the difference being due to a small amount of double cropping.

The increased production of the critical crops in these projects is of great significance. Later in this paper it will be shown that there are at least 31 million acres of similar land in the United States, which is now cultivated or partially cultivated, in need of improved drainage. If significant increases in crop production can be secured on 34,000 acres, as shown in the table, it may readily be seen that a larger program on a portion of the 31 million acres would result in increased crop production of national importance.

Typical of these 35 projects is one which I shall describe in some detail. There is a group of twelve farmers in Knox County, Indiana, who are dependent upon a community outlet known as Maria Branch. Two years ago the branch had filled up and the lowlands were nonproductive and being damaged from lack of proper drainage. The uplands were eroding and farmed too intensively to row crops. The Soil Conservation District suggested that the twelve farmers cooperate in working out their problems. The District, using the technical assistance furnished by the Soil Con-

This view is typical of the means of artificial drainage that must be relied upon for removal of excess rainfall in humid areas deficient in natural drainage

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Lafayette, Ind., June, 1943. A contribution of the Soil and Water Conservation Division.

JOHN G. SUTTON is head, drainage section, engineering division, Soil Conservation Service, U. S. Department of Agriculture.

servation Service, surveyed, designed, and supervised construction of the drainage ditch draining these twelve farms. The drain was 2½ miles long and the contract cost was $1,975, which was paid by the farmers with the total cost being prorated by a mutual agreement of the farmers involved. This was believed to be about half the cost of a ditch of similar size put through by the county court. Many improved features, including protection of banks from erosion and tile outlet protection, were incorporated in the design. Conservation plans were worked out for the farms which gave further technical assistance to farmers on working out drainage, crop rotation, and erosion control problems. Thus the entire group of farms is producing more this year as a result of the community drainage project and conservation plans which have been placed in effect largely at the cost of these farmers.

SUMMARY OF ESTIMATED ACREAGES AND YIELDS ON 35 TYPICAL DRAINAGE JOBS PLANNED BY SOIL CONSERVATION SERVICE

Crops	Acres: Before jobs started	Acres: After drainage completed	Average yields: Before jobs started	Average yields: After drainage completed	Net increase in production due to drainage	Value per unit	Estimated gross value of increased production due to drainage
Corn	7632	8484	28 bu	46 bu	175,100 bu	$1.07	$187,500
Oats	1387	915	33 bu	48 bu	- 1,500 bu	.48	- 720
Barley	465	950	32 bu	40 bu	22,740 bu	.65	14,800
Wheat	2010	2892	16 bu	21 bu	29,370 bu	1.37	40,200
Sorghum (grain)	200	150	30 bu	50 bu	1,500 bu	.66	990
Soybeans (for beans)	4021	4570	18 bu	27 bu	52,200 bu	1.66	86,700
Hay	2705	3737	1.3 ton	2.9 ton	7,530 ton	11.00	82,800
Cotton	5380	5622	0.64 bales	.79 bales	999 bales*	95.00* (lint)	114,700
Rice	25	25	43 bu	61 bu	450 bu	1.53	690
Potatoes	2498	2748	123 bu	162 bu	137,900 bu	1.10	151,700
Vegetables	1427	1587	$55	$71	$34,200		34,200
Pasture	2752	2586	743†	1165†	968,000†	.03	29,040
	30,502	34,266					$742,600

†Pounds of milk equivalent

*Cotton also produced increase of 440 tons seed valued at $45.00 per ton.

Estimates were made of the costs of the work and compared with the estimated value of the increased gross production with the following results:

1 The total drainage cost averaged $5.67 per acre, of which the farmers and drainage enterprises contributed $3.10; and the Soil Conservation Service contributed $2.57 per acre, including estimated cost of technical services rendered.

2 The estimated increase in gross production was $21.85 per acre benefited after drainage was complete.

3 Each dollar expended on the project from all sources would result in a gross increase in crop production of $3.85.

4 From the government's viewpoint each dollar expended stimulated work which would result in an annual increase in crop production of $8.47.

5 It has been found feasible to stimulate increases in production of needed war crops such as soybeans, corn, hay for beef and dairy products, potatoes, and cotton.

In the above comparison gross crop production should not be confused with net income of farmers. On certain areas farmers would need to put in shallow farm drains in addition to the drainage work planned; such work could be done by farm tractor or teams and farm labor and the estimated cost would not exceed a dollar per acre. In some areas the cost of production per acre for some crops would be greater following drainage. On the other hand, it is often cheaper to cultivate, plant, and harvest a good crop on a well-drained acre than a poor crop on a poorly drained acre.

THERE ARE SOME 87 MILLION ACRES IN ORGANIZED DRAINAGE ENTERPRISES THROUGHOUT THE UNITED STATES

Some people do not realize the extent of the drainage problem in the United States, and I think that it is worth a few minutes to review the scope and kinds of the existing drainage problems. There are, according to the 1940 census of agriculture, some 87 million acres in organized drainage enterprises. These enterprises were organized in order that groups of farmers could drain their lands by means of ditches, tile drains, levees, and pumping plants. Most of these enterprises were constructed prior to 1920. In order to maintain the lands in good producing condition, regular maintenance work should have been carried on. In limited areas the necessary maintenance operations have been carried on, but most of these operations have been neglected sadly and there are tremendous areas of land within the organized enterprises that are not now producing satisfactory yields per acre. The engineers of the Soil Conservation Service sometime ago estimated that 24,600,000 acres of cultivated lands in these organized drainage enterprises are in need of rehabilitation in the humid areas of the United States (excluding the irrigated lands). A large proportion of the drainage enterprises are in the heart of the corn belt and in the Mississippi Delta. We may be sure that at least a third of all the enterprises are in need of drainage rehabilitation.

If these drainage enterprises were all functioning properly, the lands would constitute one of the most productive agricultural resources of the country. When the problem is viewed realistically, we find that these drainage enterprises are not producing nearly the amount of food which they are capable of producing. Poor drainage conditions are so widespread that the problem is of national importance. Many ditches, which were once effective, have silted almost full, others are overgrown with brush and small trees. The carrying capacity of many ditches has been reduced to only one-quarter or one-third the capacity required. The effect of such neglect is to reduce crop production. Poor drainage may result in the inadequate removal of surface water or too high a water table. Excess water on the surface or too near the ground surface lowers the yields of crops.

Many examples could be cited to show how inadequate drainage has hindered crop production, but one example near Fennville, Michigan, impressed me as very outstanding. Near this town a considerable body of muck land has been reclaimed by drainage. This land has been highly productive during the years when the drainage was adequate, but the ditches had filled to such an extent that they were not able to drain off the heavy rain which occurred about the middle of August, 1942. The water rose over most of the muck area and remained over the crops for as long as 48 to 72 hours. This rain and poor drainage resulted in a total loss of several hundred acres of truck crops in the drainage enterprise. Fields of carrots and cabbage were examined during the first week in September, 1942. One field of carrots was almost a total loss. Some carrots appeared to be sound at the top, but on being pulled out of the ground it was found that the roots had disintegrated so that they were of no commercial value. A few sound carrots were discovered at the high points in the fields, but it was evident that there were not enough of them to justify harvesting. The farmer who owned this field had lost about $10,000 worth of truck crops on 40 acres of muck lands. He abandoned the remainder of his crop to weeds and went to work in town.

The same day a field of cabbage, which had been damaged in the same rain, was examined. It was evident that the field was a total loss. The flood water had deposited black muck among the leaves. Even if the flood had receded quickly enough so that the plants survived, these deposits of silt and muck soil would have greatly reduced the value of the crop. In this area around Fennville it was estimated that nearly $100,000 of truck crops were lost last year on over 2,000 acres.

This is a striking example and the effects were severe enough so that the farmers will improve their drains if they are able. The partial loss due to inadequate drainage is even more serious in the aggregate from a national viewpoint than those instances where a total loss of a crop occurs. There are many more fields where poor drainage reduces crop production by 25 per cent. In fact, it is often difficult for men familiar with agriculture to recognize some poor drainage conditions, especially where the difficulty is primarily due to a high water table and only a partial loss occurs. For example, there are many fields which are capable of producing 60 bushels of corn, but with less perfect drainage will produce only 45 bushels per acre. In many instances, and especially at different stages in the growth, there is little visual evidence to distinguish between the 60-bushel crop in the well-drained field and the 45-bushel crop on the partially drained field. One cannot see the high water table which retards the roots of crops in the partially drained field and results in a lower yield.

In addition to the 24,600,000 acres of cultivated land in organized drainage enterprises in need of better drainage, there are about 4,300,000 acres of unimproved land not now cultivated in these organized drainage enterprises which could be drained and brought into cultivation at reasonable cost. Typical of the undeveloped land in districts are large areas of fertile cutover land in the Mississippi Delta.

The cost of the drainage rehabilitation work would be very small in relation to the benefits. Based on experience with large-scale operations, it has been established that at least 80 per cent of the rehabilitation of open ditch work could be constructed at a cost of less than $10.00 per acre (not including tile drainage). Fortunately most of the lands requiring drainage are the more fertile lands. The reason for this is simple. Lands requiring drainage are not usually subject to excessive erosion. They are the flatter lands and were developed after the rolling lands, having natural drainage, had been broken to the plow. They have been farmed for fewer years and there is in these lands a large reservoir of fertility available for food production when drained.

THE CLEARING AND EXCAVATION OF DRAINAGE DITCHES IS THE BIG PART OF DRAINAGE REHABILITATION

In undertaking the rehabilitation, the clearing and excavation of open ditches is by far the largest portion of the job to be undertaken. There are 146,000 miles of public open drains and fully 40,000 miles of these should be rehabilitated. Each year this work is postponed, additional land will become less productive. This 40,000 miles of open drains includes only the outlet ditches in existing enterprises and does not include the farm drains and additional laterals, which should supplement and go hand in hand with outlet work. There is a substantial mileage of tile drains that should be rehabilitated. Many tile drains are filled up and must be dug out. There are in the United States 55,000 miles of public tile drains and I think it a conservative estimate that at least 10 per cent of the mileage, or 5,500 miles, needs to be dug up and relaid now to provide better drainage; 30 per cent of the total mileage needs less extensive repairs.

Next we should consider how this work can be done. Under the existing state laws, under which the drainage enterprises were organized, provisions were made for maintenance but generally maintenance and rehabilitation have been unsatisfactory. According to the 1940 census, enterprises which contained 54 per cent of the land reported that no systematic maintenance was being given the drains. Imagine what our highways would be like if on half the mileage weeds and brush were not cut on the right of way and the roads were not maintained. It has been evident that many of the drainage enterprises which carry on some maintenance are not in a position to do the work necessary to keep the drainage work up in good shape. Even where maintenance is carried on, the enterprises are usually responsive to the demands and wishes of the majority of the farmers within the enterprise. Often 10 or 20 per cent of the farmers having the least favorably situated land in a drainage district may suffer severely before the majority of the farmers are willing to undertake the necessary rehabilitation work. For this reason in many drainage enterprises there exists special small problem areas. Often farmers don't recognize or won't admit damage due to poor drainage. Assessments for work are levied in proportion to benefits, and consequently there is reluctance on the part of many to admit a benefit.

There are some drainage districts and many county officials carrying out their responsibilities and performing outstanding maintenance and rehabilitation work as the need requires. In Pemescot County, Missouri, every mile of the 600 miles of public ditches in that county was cleared by the drainage districts at their own expense in 1941. A CCC camp had been operating in that county for five years and had assisted in the rehabilitation of a large proportion of the public drains in the county. The governing body of the county realized the importance of maintenance and consequently inaugurated their effective system of maintenance. In some of the counties in northwest Ohio, ditch hearings to rehabilitate ditches are an everyday occurrence. Some large drainage districts have an adequate program of maintenance, especially if they are well organized. If the people responsible for maintenance in the various states would exercise that responsibility, a tremendous improvement in drainage conditions would result.

Many agricultural agencies that deal with farmers and farm organizations can encourage the farmers to do something about their drainage problems. If the farmers do not know what should be done or how much it will cost, it will probably pay them to hire an engineer and have a survey made and find out the cost and amount of work necessary. As has been shown by examples, the increased production the first year will more than pay for most rehabilitation and maintenance jobs. The lack of equipment to do drainage work at reasonable cost is one of the special wartime problems that is critical in many areas.

In addition to the lands which have already been drained, there still remain about 100 million acres of wet, swampy, and overflow land in the humid areas of the United States. A substantial proportion of this land is in coastal marshes, land too expensive to drain, land low in fertility, and land which should be devoted to production of timber or used for recreation and wild life. Out of this 100 million acres of wet lands, there is at least 20 million acres of fertile lands which could be drained at reasonable cost, averaging less than thirty dollars per acre and which will support a high type of agriculture if drained. This cost is exclusive of tile drains and land development, such as land clearing, fencing, etc. The drainage of these lands would generally require several years to organize the areas into districts, to acquire right of ways, levy assessments, and construct main and farm drains and to clear the land and get it under production.

The drainage and development of new lands is not considered a wartime job generally. There is one exception, however, where new drainage enterprises are considered justifiable under wartime conditions. There are many farms on which partially cultivated fields normally wet, produce fair crops in dry years but which need outlet drains and better farm drains. New drainage enterprises, which can be constructed simply and cheaply and increase crop production of existing farm units, are justifiable as a wartime project in many instances. It has been estimated that there are at least 6,500,000 acres of this type of land in existing farm units which would produce more if proper outlet and farm drains were provided. The development of an extensive new drainage program after the war should offer many advantages in postwar work to provide homes and employment for returning soldiers and sailors.

THE IMPORTANCE OF FARM DRAINAGE CANNOT BE OVERSTATED IN TERMS OF INCREASED FARM PRODUCTION

At this point I wish to mention that all of the estimates of land in need of drainage given in this paper are considered preliminary estimates, and it is believed that, when more careful studies are concluded, the estimates of the acreage, which can be drained at reasonable cost, will be found larger than the figures quoted.

The importance of the farm drainage problem cannot be overstated. The crop production of a substantial proportion of the best farm land depends upon the maintenance of good farm drains. There has been a tendency for many farmers to neglect their farm drains for a long time in the same manner that public drains have been neglected. The farmer, being under pressure to reduce crop production and reduce his acreage plowed, naturally gave less attention to his farm drains. There is a big drainage job to be done on farms. Part of this job is to rehabilitate and clean out existing drains and part is to build new drains. Numerous examples could be cited where farmers, by simple drainage practices, have brought fields into cultivation which had been idle due to excess water and had secured 40 or 50 bushels of corn or good yields of other critical crops. Most generally farm drainage and outlet drainage problems are closely associated. In such instances the drainage system is not complete unless both farm drains and outlet drains are adequate in size and depth.

Nearly all soils, when drained, need a proper crop rotation with a legume in the rotation, application of lime, and often fertilizers. The Soil Conservation Service, in its drainage operations, is encouraging these and other desirable conservation practices, which together comprise the conservation plan of the area.

In connection with the farm drainage problem there seems to be growing recognition of the importance of tile drains in giving very satisfactory farm drainage. Large quantities of tile continue to be sold and installed in the Middle West to replace less adequate systems and to give better drainage to wet fields. In addition farmers are beginning to show *(Continued on page 331)*

An Analysis of the Raking Action of a Side-Delivery Hay Rake

By C. B. Richey
MEMBER A.S.A.E.

A SIDE view of the raking action of a side-delivery rake in the direction the hay is moved is shown in Fig. 1.

This shows the successive paths of the tooth points during the effective portions of their strokes. The arcs shown by solid lines represent the path of a single tooth from the point where it takes over the hay from the previous tooth to the point where it delivers it to the succeeding tooth, considering the ends of the teeth only. It can be seen that the distance from the tooth point to the ground at the lowest point during its effective stroke will be less than at the highest point during its effective stroke by the distance x. This distance, the variation in height during the effective stroke, will determine how cleanly light hay lying flat on the ground can be picked up. In heavy hay lying on a stubble, x can be larger since the teeth can get under it easier; also the fact that the hay hangs together will aid clean raking.

Fig. 1 Side view of effective raking strokes of the tooth points of a side-delivery rake

For a given rake, the distance x will depend on the rotational speed of the reel with respect to the speed of ground travel. For a given rake and velocity ratio between the drivewheels and the reel, the distance x can be readily determined by graphical means. A mathematical formula, expressing the relationship between the various factors involved, is quicker than the graphic method, however, and the effect of changing any of the various factors can be readily calculated. The derivation of such a formula follows.

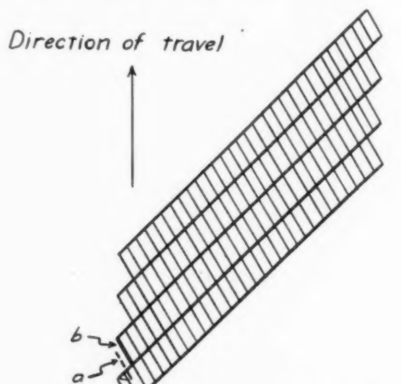

Fig. 2 Top view of four effective raking strokes of tooth points

A top view of the paths of the tooth points during their effective raking strokes is shown in Fig. 2. It can be seen that a tooth does not have to start its effective stroke at a line perpendicular to the direction of travel and passing through the point where the previous tooth on its section left off, as shown by the dotted path a, but can wait until it reaches the line parallel to the reel axis, as shown by the heavy path b. The ends of the teeth describe a circle of the same diameter as the reel, but with the center lower than the reel center by an amount equal to the distance from the tooth point to the center of the reel bar.

Article prepared especially for AGRICULTURAL ENGINEERING.
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Fig. 3 shows the complete circle described by a tooth point and the arc during the effective stroke.

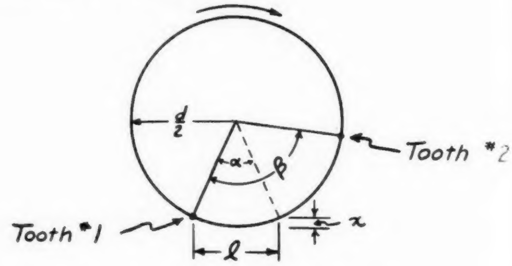


Fig. 3 The tooth point circle

Fig. 4 shows the paths of the effective strokes of the teeth on a particular section of the reel and the values of the dimensions involved.

An explanation of the symbols used is as follows:

φ = angle between reel and rake axle, usually 45 deg

τ = angle between path of effective stroke and direction of forward travel

α = angle turned by reel during effective stroke of tooth

β = angle between reel bars

l = length of chord of tooth circle during effective stroke

x = variation in height from ground during effective stroke

D = diameter of drivewheels

d = diameter of reel

R = gear ratio between reel and drivewheel.

In order that tooth No. 2 start raking at the proper point, the forward travel of the rake must equal $l \cos \varphi + l \sin \varphi \tan \varphi$ while the reel turns through an angle $\beta - \alpha$. Therefore,

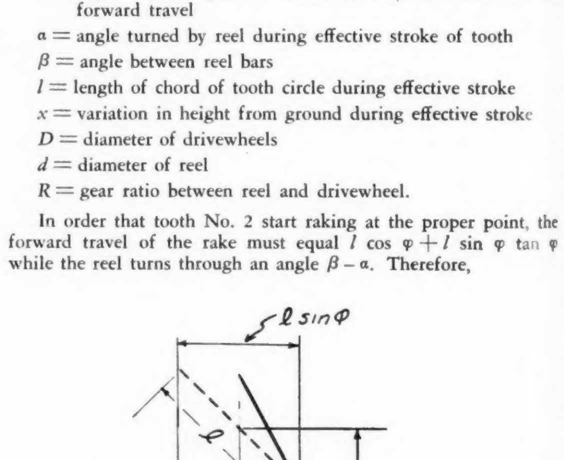


Fig. 4 Paths of effective strokes of successive teeth on a particular section of the reel

$$R = \frac{\beta - \alpha}{\left(\dfrac{l \cos \varphi + l \sin \varphi \tan \varphi}{D\pi}\right) 360}$$

$$= \frac{D\pi\,(\beta - \alpha)}{l\,(\cos \varphi + \sin \varphi \tan \varphi)\ 360}$$

$$\text{Also } x = \frac{d}{2} - \sqrt{\left(\frac{d}{2}\right)^2 - \left(\frac{l}{2}\right)^2}$$

$$\text{And } \tan \tau = \frac{l \sin \varphi}{l \cos \varphi + \dfrac{D\pi}{R}\left(\dfrac{\alpha}{360}\right)}$$

As an example of the use of the formula, let us consider a three-bar rake with 44-in wheels, 22-in reel set at 45 deg, and to be geared to have a variation of 0.6 in in height during the effective portion of the stroke. In this case; $\varphi = 45$ deg, $\beta = 120$ deg, $x = 0.6$ in, $D = 44$ in, and $d = 22$ in.

$$\text{Since } x = \frac{d}{2} - \sqrt{\left(\frac{d}{2}\right)^2 - \left(\frac{l}{2}\right)^2}$$

substituting for d and x and solving for l gives

$$l = 7.16 \text{ in}$$

$$\text{Since } \sin \frac{\alpha}{2} = \frac{l}{d}$$

substituting the values for l and d gives

$$\alpha = 38 \text{ deg}$$

$$\text{And since } R = \frac{D\pi\,(\beta - \alpha)}{l\,(\cos \varphi + \sin \varphi \tan \varphi)\ (360)}$$

substituting and solving for R gives

$$R = 3.11 \text{ to } 1$$

$$\text{Also } \tan \tau = \frac{l \sin \varphi}{l \cos \varphi + \dfrac{D\pi}{R}\left(\dfrac{\alpha}{360}\right)}$$

which gives

$$\tau = 27 \text{ deg } 20 \text{ min}$$

Now let us consider a four-bar rake of the same dimensions which is to be geared to have the same variation in height during the effective stroke: $\varphi = 45$ deg, $\beta = 90$ deg, $x = 0.6$ in, $D = 44$ in, and $d = 22$ in. Since x and d are the same, $l = 7.16$ in and $\alpha = 38$ deg, the same as with the three-bar rake.

Following the same procedure as above, we find that

$$R = 1.97 \text{ to } 1 \text{ and } \tau = 22 \text{ deg.}$$

The average distance the hay will be moved can be measured from the center of the strip raked to the center of the windrow along the angle τ. If the width raked is 7 ft and the windrow is 2 ft wide, this distance will be 9.8 ft with the three-bar rake and 12 ft with the four-bar rake. Because of the greater amount of work done on the hay, the four-bar rake should have a higher draft.

The resultant velocity of the teeth during the effective portion of the stroke will be 2.36 times the forward velocity of the rake in the case of the three-bar rake and 1.82 times the forward velocity in the case of the four-bar rake. This of course is an advantage for the four-bar rake because it will rake the hay more gently, reducing the loss of leaves if the hay is dry. Also, there should be less strain on the teeth because of the reduced impact stresses.

Because the four-bar rake moves the hay farther and rolls it up more, it would seem that there would be more of a tendency to deliver a windrow of uneven size where the rake changed direction slightly. In order to overcome this tendency and reduce the draft but yet handle the hay gently, it might be necessary to use a longer reel set at a larger angle φ. This in turn would have the practical handicap of increasing the cost of the machine and the storage space required.

Drainage to Increase Food Production

(Continued from page 229)

interest in tile drainage in areas where the practice has not been common. For example, several tile drainage systems were installed within the last year in the coastal plains of South Carolina in an area where the practice was not well known.

Many of the drainage problems can be solved with the financial aid of the farmers involved, provided there is leadership in getting the farmers together and good technical plans available to guide the work. The Soil Conservation Service is attempting to provide these services to soil conservation districts with the limited resources and technicians available for this work. Many worth-while projects have been undertaken on this basis.

In addition to the drainage problems which can be undertaken by the farmers at their own expense, there is a large acreage of poorly drained land which the farmers cannot drain at their own expense. In many localities farmers have not developed successful methods of draining their wet lands with their own resources. It is clearly in the public interest that much of this land be improved as quickly as methods can be developed for accomplishing the objectives. The Soil Conservation Service has undertaken numerous demonstrations this year which have previously been described in some detail. These will provide considerable increase in food production. It is hoped that they will stimulate many other groups of farmers to undertake similar work even though they are rendered no assistance. Although progress is being made, the facilities available are sufficient to solve only a small part of the entire problem.

"Home Dehydrators . . . ."

TO THE EDITOR:

SINCE I have not written any letters of commendation for the many fine articles published in our Journal, I hesitate to criticize articles which to me might better go unpublished. I have a very hazy recollection of such an article . . . . some 15 years ago . . . . and now Larry Porter comes out with a somewhat sarcastic criticism of several of our (A.S.A.E.) members who have been conducting experimental work on home dehydrators at a time when dehydration seemed to have some possibilities in view of the government expressions concerning the unavailability of home canning equipment.

In addition to what I feel is unwarranted criticism of the work of such people, the article itself contains misleading information as well as some very appropriate and worth-while information. For instance, Mr. Porter's reference to an estimated cost of 27c for 10 hr continuous operation of a 900-w dehydrator having a capacity of 10 lb does not jibe with a leaflet which I received yesterday describing a dehydrator manufactured by his own company having a capacity of 20 to 25 lb with a heating element of 120 w for normal operation, although having an additional 1,000 w for bringing the product up to the drying temperature.

It is somewhat inconsistent to criticize the use of infrared drying lamps with more than one tray when, so far as I personally know, the only model of such design was publicized through a magazine published by his own company. Such criticism in the light of the rest of this article might well be taken as being directed toward the same people who have been doing experimental work along different lines.

Personally I feel that an article criticizing other people for publishing information concerning equipment without complete field tests should not include recommendations suggesting "reasonably satisfactory results by making a frame to hold the trays and simply placing over it a corrugated paper carton." A criticism for using nine 100-w lamps readily available in rural areas as against three 300-w lamps less readily available might not be as serious as the suggestion that homeowners use a comparatively expensive radio clock timer presently available to only one farmer in several thousands.

I believe that the information concerning the best type of lamp, if the lamp is used in dehydrators, would be appreciated by workers in the field . . . . .

Since I have had no connection with the experimental work being done on dehydration, I feel free to offer this criticism . . . .

IRA L. KNOX

Chattanooga, Tenn.

Moisture Percentages — Their Use and Abuse

By A. W. Clyde
FELLOW A.S.A.E.

MOISTURE percentages are evidently confusing to some who are using them. Mistakes in dealing with such figures have appeared in several recent articles on drying; in fact, incorrect procedures in dealing with percentages are rather common. Most people can understand that an increase from 100 to 125 is a 25 per cent increase, but some are bothered by the fact that a decrease from 125 to 100 is a 20 per cent decrease. The author has talked with a number of men in other fields and finds some haziness as to why moisture percentages are calculated as they are, and what can be done with the percentages.

Two common ways are used for expressing moisture percentage, as follows:

1 *Wet basis.* Moisture given as a percentage of sample weight (dry matter plus moisture); commonly used for hay, grain, vegetables, and some chemicals. In several dairy products the percentage of solids is customarily given. This is 100 minus the per cent moisture on the wet basis.

2 *Dry basis.* Moisture given as a percentage of dry matter in sample; commonly used for soil, sand, lumber, ceramic and other building materials, also in chemical engineering work.

Either basis is permissible. No valid reason except custom exists for using one basis with some materials and the other basis for other materials. Either one can be converted to the other by the equation or curve shown in the accompanying graph. This equation is derived as follows:

Let $x =$ per cent moisture on wet basis, $y =$ per cent moisture on dry basis, and $a =$ weight of dry matter in sample.

The total weight of the sample on the wet basis is $a/(1-x/100)$, while this same weight on the dry basis is $a + (ya/100)$. These two expressions for the same value are equated and simplified into $100y - xy = 100x$.

Some object to percentages over 100, as may occur when the dry basis is used. As an extreme example, spinach with 90 per cent moisture on the wet basis is 900 per cent on the dry basis. Whether or not we object to a percentage over 100 depends largely on our habits of thought. The argument against it seems rather flimsy; we often speak of an increase of more than 100 per cent. If our conviction against high percentages is deep seated, we can say that the moisture-dry matter ratio is 1.5 to 1, 9 to 1, or whatever it happens to be. It is very rare for an author to say which basis he is using. In most cases the reader can only guess, guided by what he may know is customary. To remove all element of doubt, the basis ought always to be indicated. Such indication might also inspire confidence that the author is familiar with the two methods.

The common mistake when using the wet basis is illustrated by the following:

Moisture before treatment	60%
Moisture after treatment	15%
Moisture removed	45%

The mistake here is evident if we ask, "45 per cent of what?" In this case, 60 is a percentage of one weight, and 15 is a percentage of another weight. Hence, subtracting one from the other is like trying to subtract horses from cows. Addition of such figures would also be incorrect. In contrast to this, if we use the dry basis, we can add or subtract percentages, if we wish, because they are always a percentage of the same thing. We have a constant base instead of a shifting base.

Following is an example of how the same sample might be handled on either basis: A sample of 100 g contains 60 g of moisture and 40 g of dry matter. It is dried until it weighs 50 g. On the wet basis this could be given:

Moisture before treatment	60 g	(60 per cent of 100 g)
Moisture after treatment	10 g	(20 per cent of 50 g)
Moisture removed	50 g	

Manifestly, subtracting 20 per cent from 60 per cent is entirely improper. The difference, 40 per cent, is meaningless. It is not a percentage of anything in the problem.

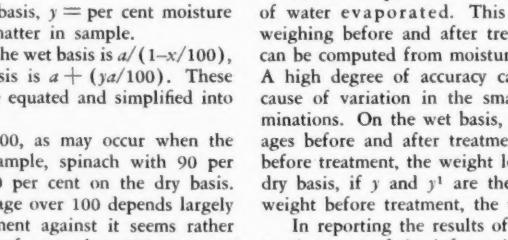
On the dry basis the comparable figures are:

Moisture before treatment	60 g	(150 per cent of 40 g)
Moisture after treatment	10 g	(25 per cent of 40 g)
Moisture removed	50 g	

Here, if desired, we can subtract 25 per cent from 150 per cent and say that the weight of moisture removed is 125 per cent of the weight of the dry matter. We should not say, however, that the treatment removed 125 per cent of the moisture in the sample.

One of the pertinent results of a drying experiment is the weight of water evaporated. This can be obtained most accurately by weighing before and after treatment. If that is not convenient, it can be computed from moisture percentages and the original weight. A high degree of accuracy can hardly be expected, however, because of variation in the small samples used for moisture determinations. On the wet basis, if x and x^1 are the moisture percentages before and after treatment, respectively, and b is the weight before treatment, the weight lost is $b\,(x - x^1)/(100 - x^1)$. On the dry basis, if y and y^1 are the respective percentages and b is the weight before treatment, the weight lost is $b\,(y - y^1)/(100 + y)$.

In reporting the results of drying experiments some may prefer to give most of the information as "percentage weight reduction." This seems most applicable where several tests are reported on materials of fairly uniform moisture. It might well be supplemented with a statement of initial and final moisture contents.



Either by the equation or the curve shown here, moisture percentages on the *wet* basis can be converted to the *dry* basis, and vice versa

CONCLUSIONS

1 Moisture percentages can be given on either basis (wet or dry), custom probably being the deciding factor as to which is used with each material. No one can say conclusively that one is right and the other wrong, though one may have advantages of convenience.

2 Standardizing on one basis would be desirable. Until this is done, all reports of moisture percentages should indicate clearly which basis is used so that the reader will have no cause for doubt.

3 When the wet basis is selected, addition or subtraction of percentages is prohibited because the base is a variable or shifting one. In much drying work the amount of water removed is an important item, but computing this from moisture percentages on the wet basis is a process in which mistakes are likely to be made.

4 The dry basis is best adapted to simple calculations because the base for percentages is a fixed one.

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Bluegrass Terrace Outlet Channels

By Dwight D. Smith
MEMBER A.S.A.E.

GRASS outlet channels for terraced fields, and as waterways for contoured and strip-cropped fields, have in practice proved to be the most economical means for disposing of excess storm runoff. These channels have been designed from known hydraulic information generally secured from drainage or irrigation experiments. The channel bed slopes, cross sections, and vegetative lining as used in erosion control work differ appreciably from the condition of the older drainage and irrigation experiments. For this reason the USDA Soil Conservation Service established an outdoor hydraulic laboratory at Spartanburg, S. C. in 1936, and another at Stillwater, Okla., in 1941. To supplement the work of these laboratories in the testing of bluegrass and the corn belt grasses not generally adapted to the more southern climates of these two locations, a small supplementary laboratory was established at the Soil Conservation Experiment Station near McCredie, Mo.

An earth fill dam provides the water supply reservoir for the testing at McCredie. The reservoir has a capacity of 100 acre-feet, of which 60 acre-feet are available for use at the maximum testing rate of 60 cfs. The control headworks at the dam, and the supply channel for conducting the water to the test channels, have a maximum capacity of a little over 60 cfs. This flow is equivalent to the calculated maximum 10-yr frequency runoff from a 17-acre cultivated terraced field[1].

Three experiments have been planned and partially completed to date. They are:

(a) The slope experiment, in which six bluegrass sod channels were subjected to various rates of flow. The bed slopes of the six channels were 1, 4, 8, 12, 16, and 20 per cent. These channels have the relatively small cross section of 2-ft bottom with 2on1 side slopes, so that high velocity flows are possible.

(b) The cross-section experiment, in which bluegrass sod channels of three different cross sections but with the same bed slopes will be tested with various rates of flow. The cross sections to be tested are: (1) 2-ft bottom with 2on1 side slopes, (2) 6-ft bottom with 4on1 side slopes, and (3) V-shaped with 6on1 side slopes.

(c) The grass age experiment, in which individual grasses and grass mixtures which have been developed from seeding will be subjected to various flows when 1, 2, and 3 years of age. These channels with four sections each, on a 4 per cent slope, and with 6-ft bottom and 4on1 side slopes, were seeded in the spring of 1941. The grasses included are: (1) a mixture of timothy and redtop, (2) Canada bluegrass, (3) Kentucky bluegrass, and (4) Brome grass.

The testing that has been done so far has consisted of one series of tests on the slope experiment channels, and on the one and two-year-old channels of the grass age experiment. This report will deal primarily with the slope experiment data, with only a few comments on the other two experiments.

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Lafayette, Ind., June, 1943. A contribution of the Soil and Water Division. (Soil Conservation Service, U. S. Department of Agriculture, and Missouri Agricultural Experiment Station cooperating. Contribution from the Department of Soils. Journal Series No. 907)

DWIGHT D. SMITH is project supervisor, Soil Conservation Experiment Stations, Columbia, Mo.

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[1]Bulletin 434. The Missouri Soil Saving Dam. Mo. Ag. Exp. Sta.

Bluegrass Sod. These channels were sodded with Kentucky bluegrass sod from a Putnam silt loam area in the late spring of 1941. The channels were excavated into the glacial subsoil to the desired bed slope. A backfill of 6 in of Putnam topsoil was then added after applying a soil treatment of well-rotted manure, lime, and superphosphate fertilizer. After the sod was in place it was given an application of nitrate of soda. The sod was mowed as necessary.

The tests were conducted during the first half of October 1942. At that time the new fall growth of the sod was 4 to 6 in high, and the annual grasses were partially dead from a frost which occurred the last week of September.

Vegetation readings were made before the tests by use of the point quadrat apparatus with the 10 needles set at an angle of 45 deg. The results of these readings are summarized in Table 1. The bluegrass sod on these channels had an average density factor of 2.44, which may be considered of about average quality. A sod of excellent density would have a factor between 4 and 5 for a maximum height of 5 in. The vegetation other than bluegrass is an annual grass locally known as foxtail. The amount of foxtail present in the sod was exceptionally large, due to the abnormally high rainfall during June, which was detrimental to the bluegrass but favorable to the annual grass.

Measurement of Flow, Velocity, and Scour. Measurement of flow was by use of a 4-ft Parshall flume without throat and diverging section. This flume was bolted to an entrance section extending through the berm of the supply channel. The entrance section included a sluice gate. The flow passed directly from the flume discharge into a connecting flume and to the test channel. The connecting flume was set on a slope computed to give the normal flow velocity at the entrance to the test channel for the maximum rate of flow.

TABLE 1. SUMMARY OF VEGETATION DATA FROM THE SLOPE EXPERIMENT CHANNELS AS DETERMINED BY THE POINT QUADRAT APPARATUS

Channel No.	Bed slope, %	Number of strikes per 240 needles at different levels above the ground surface				Strikes per needle	Per cent bluegrass*
		>0.4 ft	0.4-0.2 ft	0.2-0 ft	Total		
6 a	1	27	324	389	740	3.09	65
b	4	12	230	344	586	2.44	78
c	8	2	132	302	436	1.82	64
1	12	13	206	331	550	2.29	74
2	16	16	235	374	625	2.61	78
3	20	4	232	340	576	2.40	87

*Vegetation other than bluegrass is annual grass.

Measurement of ground surface elevation and water surface elevation were made by use of point gages supported on wooden beams across the test channel at three locations spaced 10 ft apart for determination of the area and velocity of flow. Piano wire stretched across the channel above the beams was the reference line for the readings. Elevation of the wire was determined by use of an engineer's level for calculation of the water surface slope. Ground surface readings before and after each test formed the basis for computing the scour occurring during each test. These readings, as well as the water surface readings, were taken every 0.5 ft across the channel. Fig. 1 shows the beams, wires, point gages, and walkways after a test had been completed, and also the three observers taking water surface readings during the 60-cfs flow on the 12 per cent slope channel. Average velocity of flow was 13.5 fps.

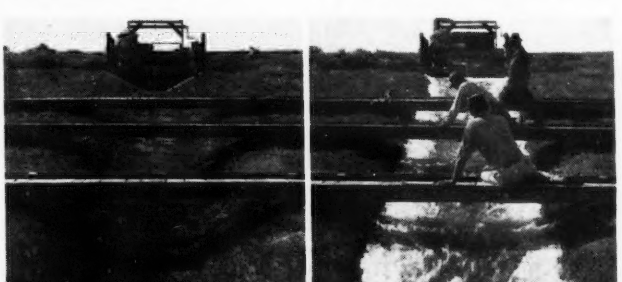


Fig. 1 Bluegrass sod channel with a 12 per cent bed slope. (Left) After the 45-cfs test had been completed, showing the beams, wire, point gages, and walk-ways which were used for taking ground and water surface readings. (Right) The three observers taking water surface readings during the 60-cfs test. Average velocity of flow was 13.5 fps

Testing. The tests were

performed in steps of increasing rate of flow. The duration of flow for each test was 50 min. Six tests were made on each channel at flows approximating 5, 10, 20, 30, 45, and 60 cfs. Three sets of water surface readings were taken at each of the three stations on a given channel after flow through the flume became uniform. The observers rotated positions so that each of the three men made water surface readings at each station during the test.

These tests showed that bluegrass sod could withstand very high velocities of flow without deterioration of the channel if a few conditions had been met in construction of the channels. In the McCredie tests about 10 acre-feet of water was passed through each channel in a period of 1½ days. The average velocities of flow varied from 2 to 15 fps. On the 20 per cent slope channel which had the steepest slope, the average velocity varied from 7 to 15 fps. Fig. 2 shows the grass of the 20 per cent slope channel before and after the six tests.

Fig. 2 Bluegrass sod channel with a 20 per cent bed slope. (Left) Before the tests. (Right) After six tests with average velocities ranging from 7 to 15 fps. Total flow through this channel was about 10 acre-feet of water. Cross section was 2-ft bottom and 2 on 1 side slopes

Excavation for the 20 per cent slope channel was 6 ft into the subsoil at the lower end. A seep which was not drained caused a saturated soil condition in the lower 5 ft of the channel and killed the bluegrass sod. While other grasses were growing on this area, they cut out during the first test, allowing the channel to cut back to a point midway of the second reach, where a mole had tunneled across the channel the night before the test. Thus two points of weakness, which should be avoided for maximum hydraulic traffic on bluegrass sod, were present when the tests started.

The bluegrass sod of the 20 per cent slope channel was of average density and about 6 in long at the time of the tests. It was thick enough to provide complete shingling of the ground surface during flow.

It was observed that an appreciable change of alignment, either horizontal or vertical, that required the sod to resist the change of direction of the water velocity resulted in damage, the extent of the damage increasing with the degree of abruptness of the alignment change and the magnitude of the velocity. Increases, however, in degree of bed slope from 1 to 4, and from 4 to 8 per cent, did not result in any damage to the sod by the flowing water.

TABLE 2. SCOUR IN SURFACE INCHES OF SOIL REMOVED PER HOUR OF FLOW AT THE INDICATED AVERAGE VELOCITY IN FEET PER SECOND. BLUEGRASS SOD CHANNELS. TWO-FOOT BOTTOM AND 2 ON 1 SIDE SLOPES

(For variation in vegetation refer to Table 1)

Channel No.	Bed slope, per cent	Velocity and Scour	Test 1	2	3	4	5	6
6A	1	Velocity, ft/sec	2.2	2.9	3.7	4.1	4.8	5.4
		Scour, in/hr	.005	.021	0	0	.001	.002
6B	4	Velocity, ft/sec	3.6	4.7	6.0	6.6	7.6	8.6
		Scour, in/hr	.015	.018	.037	.045	.018	.023
6C	8	Velocity, ft/sec	5.1	6.6	8.4	9.5	10.8	12.0
		Scour, in/hr	.056	.011	.043	.066	.037	.074
1	12	Velocity, ft/sec	5.7	7.7	9.4	11.4	12.5	13.6
		Scour, in/hr	0	.044	.120	.024	.053	.042
2	16	Velocity, ft/sec	6.2	8.2	10.4	11.9	13.2	14.3
		Scour, in/hr	.021	.019	0	.003	.046	.029
3	20	Velocity, ft sec	6.9	8.9	11.3	12.7	13.9	14.7
		Scour, in/hr	.010	.062	.094	0	.076	.072

Scour. Very little scour occurred in any of the bluegrass sod channels during the six tests. The stems and blades of the grass formed a shingle-like covering to the channel bottom and sides, with the roots acting as the nails to hold the shingles in place. On some of the channels the shingling was not complete and at these places the first evidence of scour was noted. The flowing water first removed the dead organic matter, leaving a fibrous mat of dead roots. As the velocity increased these dead roots were removed, followed by a layer of surface soil. This left some live roots visible at the upstream side of the sod clumps. In general, the holes did not exceed 1 in in depth and in no case were complete sod clumps washed out.

Table 2 lists the average rate of scour in surface inches per hour throughout the wetted perimeter for each test and channel. The average velocity of flow for each particular test and channel is also given. The density of the grass in each channel is given in Table 1. These values of scour at first appear somewhat erratic. Some of the variation is of course due to experimental error, as reading of the ground surface was different, particularly after the soil was soft from water saturation. There was a tendency for rate of scour to increase more rapidly during the first or lower velocity tests, than for the higher velocity tests.

The relationship between scour as the dependent variable, and average velocity of flow and density of grass as two independent variables, was tested by statistical methods. The coefficient of multiple correlation assuming linear relationships was first tried. The value of the coefficient was 0.56, which may be considered as highly significant. Other determinations were made in an effort to secure a more theoretically correct estimating equation and a higher degree of correlation. Not all possibilities were tried, but of those made the following appeared the most satisfactory:

$$Sc = 0.044 + .018V^{\frac{1}{2}} - .025G$$

in which Sc = rate of scour in surface inches per hour
V = average velocity of flow in feet per second
G = density of grass in average number of strikes per quadrat needle.

The standard error of an estimate based on this equation was 0.0251. This may be interpreted to mean that any one estimate of the rate of scour by use of the equation would be correct to within 0.017 in per hr 50 out of 100, or to within 0.051 in per hr 95 times out of 100. The coefficient of multiple correlation for this estimating equation was 0.584. According to the standard method of determining significance, the coefficient may be considered highly significant as the value of the multiple correlation for the 1 per cent level of significance is 0.494.

TABLE 3. DATA OF THE SLOPE EXPERIMENT TEST FLOWS ON BLUEGRASS SOD CHANNELS OF 2-FT BOTTOM AND 2 ON 1 SIDE SLOPES. TESTS PERFORMED OCT. 7-16, 1942. VALUES GIVEN ARE AVERAGES OF SIX DETERMINATIONS

Channel and Test No.	Temperature of water, F	Cross section area of water, sq ft	Hydraulic radius, ft	Average velocity, fps	Energy gradient, ft/ft	Manning's n
6A - 1	61	2.833	.517	2.17	.0147	.0518
2	61	3.707	.624	2.86	.0141	.0450
3	61	5.517	.782	3.69	.0130	.0379
4	60	6.706	.872	4.05	.0124	.0358
5	60	8.886	1.007	4.79	.0111	.0309
6	60	10.964	1.126	5.44	.0092	.0263
6B - 1	61	1.725	.392	3.58	.0385	.0437
2	61	2.254	.460	4.68	.0372	.0365
3	61	3.374	.596	6.00	.0357	.0331
4	60	4.113	.663	6.58	.0357	.0325
5	60	5.566	.806	7.64	.0318	.0301
6	60	6.955	.914	8.57	.0320	.0293
6C - 1	61	1.202	.298	5.14	.0752	.0354
2	61	1.598	.361	6.60	.0739	.0311
3	61	2.409	.462	8.41	.0783	.0296
4	60	2.852	.503	9.48	.0750	.0272
5	60	3.952	.611	10.75	.0733	.0270
6	60	4.946	.682	12.04	.0666	.0247
1 - 1	62	1.012	.280	5.68	.119	.0387
2	62	1.468	.364	7.65	.117	.0338
3	61	2.033	.437	9.44	.112	.0305
4	61	2.513	.489	11.35	.111	.0271
5	63	3.489	.580	12.54	.110	.0273
6	63	4.277	.663	13.55	.104	.0269
2 - 1	60	.926	.274	6.19	.159	.0403
2	60	1.329	.324	8.16	.159	.0343
3	60	1.841	.401	10.39	.158	.0309
4	63	2.364	.461	11.86	.157	.0296
5	60	3.257	.540	13.24	.146	.0285
6	60	4.154	.622	14.27	.134	.0278
3 - 1	59	.841	.241	6.94	.213	.0382
2	59	1.197	.305	8.92	.204	.0341
3	59	1.725	.359	11.30	.180	.0282
4	59	2.353	.445	12.71	.181	.0290
5	60	3.263	.524	13.90	.163	.0280
6	59	3.944	.596	14.70	.182	.0305

Retardance. Retardance values as expressed by the factor n in the Manning formula were calculated from the test data listed in Table 3. The slope factor S used in the calculations was the slope of the energy gradient. The values of n as determined were somewhat smaller than generally used in field practice. Velocity of flow, however, was appreciably higher than used in field design, except on the 1 per cent slope section.

Retardance decreased with increased slope and hydraulic radius and decreased density of vegetation. The relationship of these variables as determined by the method of least squares for an exponential equation was as follows:

$$n = \frac{.0106\ G^{.43}}{R^{.48}\ S^{.15}}$$

in which n = retardance factor in the Manning formula
R = hydraulic radius in feet
S = slope of the energy gradient, also bed slope and water surface slope for uniform flow of constant depth, in feet per foot
G = density of grass in average number of strikes per quadrat needle.

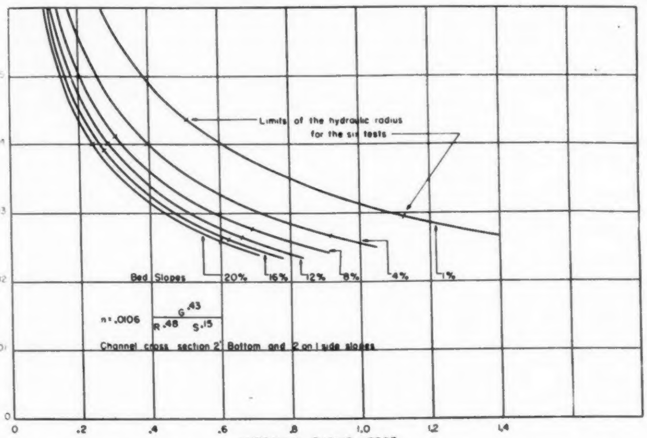


Fig. 3 Calculated values of Manning's n by use of estimating equation derived from the experimental data. Value of the grass density factor was 2.50, and of the slope factor the hydraulic slopes for the six different bed slopes

The index of multiple curvilinear correlation was 0.890, which is considerably above the value of 0.494 required for the 1 per cent level of significance. The standard error of estimate based on the equation and as a logarithm was 0.03300. This may be interpreted to mean that 67 times out of 100 the logarithm of n determined by the estimating equation will not differ from the observed value more than 0.03300, or on a percentage basis the calculated value of n would not differ from the observed value by more than 17 per cent, 95 times out of 100.

With vegetation such as bluegrass, the resistance of a given density of grass to flow of water will vary appreciably as the velocity and depth of flow change. Low velocity flow will pass between the stems; thus the water will contact a greater area of the grass than if the water passed only over one side of the stems and leaves, as is the case when the grass has shingled. Shingling occurs when the frictional force of the flowing water on the stems is sufficient to overcome their maximum bending moment. As the grass bends, more of it is incorporated in the flow, but the flow is greater to cause this action. As the depth and velocity of flow increase, the grass is bent over more and more until it reaches a reclining position. The increased pressure of greater depths will tend to flatten the grass more and more until it approaches a smooth plane surface, where the retardance will be little more than that of rough masonry or boards. Stiff-stemmed grasses would of course not act like bluegrass under flow.

A schematic diagram of retardance and depth of flow has been published by Cook and Campbell[2]. In the McCredie tests the lowest velocity tests on each channel was of sufficient depth and velocity to flatten the stems and leaves; thus the data are for that portion of the curve which they have labeled "vegetation shingled".

Fig. 3 shows values of n plotted against hydraulic radius as determined by the estimating equation for different bed slopes. A grass density factor of 2.5 was used in the calculations. It may be considered representative of an average bluegrass sod. The slope factor used in the calculations was the hydraulic slope for the bed slopes of the six channels with the assumption that flow would be of constant depth and velocity.

These curves represent the data quite well within the limits of the tests. They make possible a better graphical comparison than the actual data, as variation of the slope factor for a given channel and variation of the grass density factor between the different channels have been eliminated. There was an observed tendency on some of the channels for the retardance to approach a constant for the larger flows. With the type of equation used, n would approach zero with increasing hydraulic radius, but would never reach zero. It is quite probable that n will approach a minimum value greater than zero, and if so an equation of a different type would be more correct. The limits of the observed hydraulic radii for the different channels are indicated in the figure.

In the use of the values of n determined from the formula, it must be remembered that they apply only to those flows which are sufficient to cause shingling of the grass. Appreciably larger values of n would be required for lower flows.

The point at which a given grass shingles depends upon a combination of factors, including velocity, depth, time of flow, and nature of the first flow wave or front. A flow of 1.2 fps average velocity was sufficient to cause bluegrass to shingle at a flow depth of 0.44 ft on a 4 per cent slope channel. A depth of only 0.32 ft, with a 6.9-fps velocity caused bluegrass to shingle on a 20 per cent slope channel. On this latter channel shingling would probably have occurred at a depth a little over 0.2 ft.

Velocity of Flow. The velocity of flow increased with increasing slope of the energy gradient, increasing hydraulic radius and decreasing density of the sod. An equation of the exponential type was fitted to the data by the method of least squares, using the average figures for each of six tests and each of the six channels, for a total of 36 cases. The estimating equation was as follows:

$$V = \frac{149\ R^{1.15}\ S^{.66}}{G^{.46}}$$

[2]Characteristics of Some Meadow Strip Vegetation, by H. L. Cook and F. B. Campbell. AGRICULTURAL ENGINEERING. Sept. 1939, vol. 20, no. 9

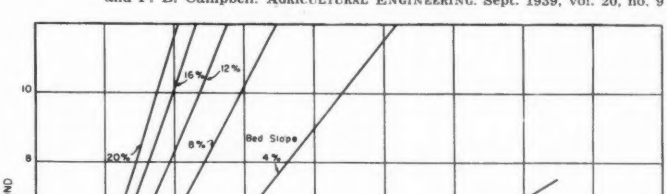


Fig. 4 Calculated values of velocity by use of estimating equation derived from the experimental data. Value of the grass density factor was 2.50, and of the slope factor the hydraulic slopes for the six different bed slopes

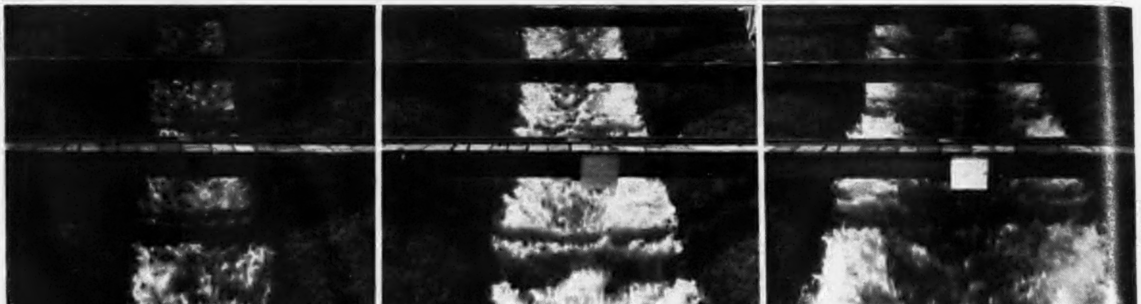


Fig. 5 The flow changes from very turbulent to a shooting type, as the average velocity increases. A bluegrass sod outlet channel of 16 per cent bed slope, 2-ft bottom, and 2 on 1 side slopes. (Left) Velocity of 6.2 fps; (Center) velocity of 10.4 fps; (Right) velocity of 14.3 fps.

The index of multiple correlation based on this relationship was 0.990. Calculated values of V differed by less than 5 per cent from the observed values for 76 per cent of the cases. The standard error of estimates expressed as a logarithm was 0.02826.

Fig. 4 shows the variation of velocity with hydraulic radius as calculated by the equation. A grass density factor of 2.50 was used the same as in calculation of retardance in Fig. 3. The slope factor was the hydraulic slope for the bed slope given, assuming uniform depth and velocity of flow.

A different type of flow appeared to develop with increasing velocity. For velocities of 4 to 7 fps, the surface was very rough from one side of the channel to the other, and with a fairly uniform distribution of white caps. This is shown in the left view of Fig. 5, where the velocity averaged 6.2 fps. As the velocity increased, the flow in the center of the channel became more shooting in nature, and the white caps began to disappear except at the edges of the channel. This is shown by the center view of Fig. 5, where the velocity averaged 10.4 fps. In the right view of Fig. 5, where the average velocity was 14.3 fps, the white has almost completely disappeared from all but the edges of the channel.

For flows above 2 to 3 fps average velocity, the water surface elevation was very difficult to read. However, averages of several surface readings checked fairly well between different individuals. As the flow increased, reading became more difficult due to the shooting lines of flow parallel to the channel. For the maximum flow rest on the 20 per cent slope channel, the observed velocity of flow was 14.7 fps. The calculated velocity of flow by the equation was 17.8 fps. This was the greatest deviation from the observed value of all the 36 cases. It is thought that the observers read the elevation of the water surface too high, resulting in a larger water cross section area and consequently an observed velocity lower than the true value. A continuous spray of water was hitting the observers in their faces during the flow.

The use of the velocity equation for design purposes could be expected to give very satisfactory results within the range of the test data. Its range of usefulness in terms of velocity would be from 2 to 13 fps, or for flow condition after the grass has been bent to shingle the channel.

Cross Section. The hydraulic radius was used in both the retardance and velocity equations to measure the channel perimeter, and the depth-width relationship as expressed by the cross-section area. As channels of different cross-section shapes could have different depths and widths for the same hydraulic radius, some variation in n as computed could be expected for a channel of different cross section. Also, a wide channel would have a smaller percentage of the cross-section area of flow occupied by "slack water"[2] than a narrow one as used in these tests. Completion of tests on the cross-section experiment channels is expected to give some definite information on the magnitude of the possible variation of n with different cross section shapes, but the same values of R.

Grass Age. Only the one and two-year-old grass channels of the grass age experiment have been tested. Kentucky bluegrass one year old withstood velocities of flow up to 3 fps without serious scour, whereas timothy and redtop one year old withstood velocities of 7 fps without serious damage. While the data from the tests on the two-year-old grasses have not been calculated, observations showed definitely that Kentucky bluegrass gave the best protection to the channel, of the four grass mixtures. Scour in it was negligible for velocities of about 7 fps. Scour in the two-year-old timothy-redtop section appeared about the same as for the tests at one year of age. The extent of the scour for the two-year-old timothy-redtop section, while appreciably more than for the two-year-old bluegrasses, was not serious.

About all practical means were used to assure a high level of fertility in the soil of the seeded channels. The success of the grass in withstanding high velocities can be attributed largely to this fact. Fertility is of first degree importance for a seeded outlet. With high fertility, a favorable soil structure, a desirable cross section, normal moisture, and a seed mixture containing timothy-redtop, Kentucky bluegrass, and white clover if available, an outlet channel can be developed in a year's time for satisfactory service on Putnam silt loam soil. The Putnam soil is relatively low-fertility soil; therefore generous use of commercial fertilizers and barnyard manure are required to bring it to a high level of fertility.

SUMMARY

1 Hydraulic characteristics of bluegrass and other corn-belt grasses are being studied at the McCredie Station.

2 This paper reports the results of the bed slope experiments on bluegrass sod, with a few comments on the channel cross section and the grass age experiments.

3 Results of the studies that are reported are for flows of sufficient depth and velocity to cause the bluegrass to shingle.

4 Bluegrass sod withstood a velocity of 15 fps without appreciable damage.

5 Bluegrass will not live in a wet, seepy channel, or in channels with slopes of much less than 1 per cent on Claypan soils.

6 Rodents can cause damage which will result in failure of the channel under high velocity flows.

7 Bluegrass sod should have a density of 2.5 strikes per quadrat needle for flow velocities above 4 fps.

8 Complete shingling of the channel by the grass is necessary for prevention of scour for velocities above 2 fps.

9 Increase in degree of bed slope in a channel will not cause excessive scour, while decrease of bed slope or other channel misalignment will cause increased scour that may lead to failure.

10 Scour increased as the square root of the velocity, and decreased as the first power of the grass density.

11 Retardance as expressed by Manning's n, decreased with increased hydraulic radius and slope and decreased grass density. The relationship was exponential.

12 Observed retardance value varied from 0.052 for a hydraulic radius of 0.52 and a grass density of 3.1 on a 1 per cent slope, to 0.025 for a hydraulic radius of 0.68 and a grass density of 1.8 on a 12 per cent slope.

13 Velocity increased as the hydraulic radius and slope increased and as the grass density decreased. The relationship was exponential.

(Continued on page 342)

Building and Maintaining Terraces with Ordinary Farm Machinery

By L. G. Samsel
MEMBER A.S.A.E.

TERRACE building in wartime deserves more than ordinary consideration. In addition to conserving soil and rainfall, terracing projects where needed have proved to increase crop yields materially, and as a part of contour farming they reduce the power required for many operations.

A tractor in pulling a load uphill is either being overloaded or has more rated power than is necessary to pull the same load downhill or on the level. In either case extra fuel is used. It is well known that overloading or underloading a tractor uses more fuel for the amount of work done than operating the tractor at its rated load. If an arrangement can be arrived at whereby all farming operations can be performed "around the hill" or following contour lines, it represents a saving in power and in tractor fuel.

No discussion of terracing would be complete without making some mention of outstanding contributors to improvements or changes over the early bench or ridge type terraces. P. H. Mangum is believed to be the first to build a terrace that could be farmed like the rest of the hillside. The findings of C. E. Ramser following investigations started in 1915 were extensively used in later terrace developments, while M. L. Nichols' experiments suggested the desirability of a water channel above the terrace ridge.

In developing a new type of terrace, two important factors have required consideration. The first has been the specifications for the most desirable and practical type of terrace for different sections of the country. The second has been to keep these specifications within the capabilities of available equipment for building the terraces.

A review and summary of current literature on terrace building describes three general types of terraces to meet the requirements of the eastern, Midwest and Great Plains areas. Because of the steeper cultivated slopes in the eastern and southeastern states, the drainage type terrace recommended has a somewhat narrower channel than terraces used farther west. This narrower channel does not appear to interfere to any great extent with the operation of farming equipment common to those states.

For Midwestern states, most of the terraced slopes being less abrupt and with larger, wider cutting equipment being used, an 18 to 20-ft water channel appears to be standard; while for the western or Great Plains areas, the recommended absorptive type terrace has a 30-ft main water channel and a smaller 10-ft channel below the terrace ridge. This lower channel is level or graded the same as the larger upper channel.

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Lafayette, Ind., June, 1943. A contribution of the Power and Machinery and Soil and Water Conservation Divisions.

L. G. SAMSEL is member of the advertising staff of the J. I. Case Co.

AUTHOR'S NOTE: Acknowledgment is made to members of U. S. Department of Agriculture, Soil Conservation Service, for helpful suggestions and information used in the preparation of this paper.

The recommended channel depth for all three types of terraces will vary with the width of the channel, the objective being to have sufficient depth to give the terrace capacity to handle heavy rains. Expressed in terms of cross-section channel area, the minimum recommended in most sections of the country is 10 sq ft.

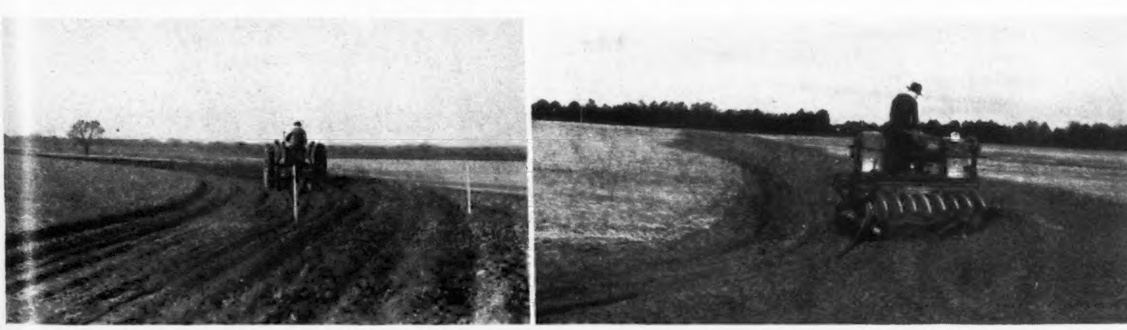
All three types of terraces have certain characteristics in common, including a broad, sweeping water channel and earth mound or terrace ridge to permit, or avoid interference with, customary farming operations. They are all intended to be structures that can be tilled and cropped like the area between terraces.

The answer to the question "What is the proper equipment with which to build terraces?" could not logically be the same for all sections of the country. In a broad sense the answer to the question might be: "The proper terracing equipment is that which builds an acceptable terrace in the least time, at the least expense, and is equipment that is readily available and easily operated". For this reason, it appears desirable to have first a set of specifications or a pattern to represent the ideal or the most desirable kind of terrace, and then to adapt or operate the equipment in such a manner as to approach as closely as possible the ideal or the pattern.

Experiments in terrace building with ordinary farm machines in the past have been made on the basis of two methods of approach. One has been the modification of the machine to make it function more as a grader, which landowners would recognize more readily as an earth-moving machine. This approach is exemplified in the attachment of blades to plow bottoms in an attempt to push the soil farther toward the terrace ridge on each trip of the implement. Another angle of approach has been to discover a system of procedure which would adapt the machine to the job without changing the machine. At the present time, this latter angle of approach appears to be the more logical and successful.

The "step-in" system of terracing with the one-way disk plow and the "island" system with the moldboard plow require no attachments nor changes in the construction of these implements. Both systems have several advantages in common. Both employ the use of regular farm equipment. Both provide exceptionally low-cost construction, not only because of the speed and accuracy with which the terraces can be built, but because no special operator or equipment is needed and because a cash outlay for new equipment is avoided. The ownership cost of the tools, furthermore, is spread out over a large number of farm jobs for which the tool can be used.

For the first phase of the "step-in" system of terrace building with the one-way disk plow, the outfit is started several feet from the point which will eventually be the center of the terrace ridge. The soil is worked inward from both sides round by round, until it meets at the stake line which marks the ridge center. This first phase of the procedure is followed for all types of terraces. It

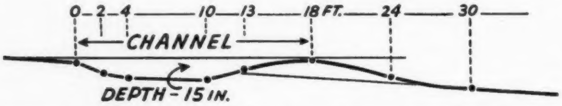


(Left) This view shows the last trip required to complete the channel development of the moldboard plow terrace. The stakes mark the position of the original "island" • (Right) This view shows completion of a second series of rounds to widen and deepen the water channel above the terrace following the "step-in" system of terrace building with the one-way disk plow

varies only with the desired width of the channel and the number of rounds required before the earth meets to start the ridge.

On the channel side this "step-in" procedure is repeated until the channel has acquired the desired depth and width, while below the ridge, in building the drainage type terrace, succeeding trips backfurrow the soil against the earth mound to gradually blend it into the slope below.

Paul M. Pittenger and others of the U. S. Soil Conservation Service are credited with the development of the "island" system of terrace building with the moldboard plow, which is in some respects similar to the "step-in" system for the one-way disk plow. Following the "island" system, the first trip of the plow is made just above and along the line of stakes which mark the terrace grade line. When the far end of the terrace has been reached, the stakes are moved downhill to mark the width of a uniform island.



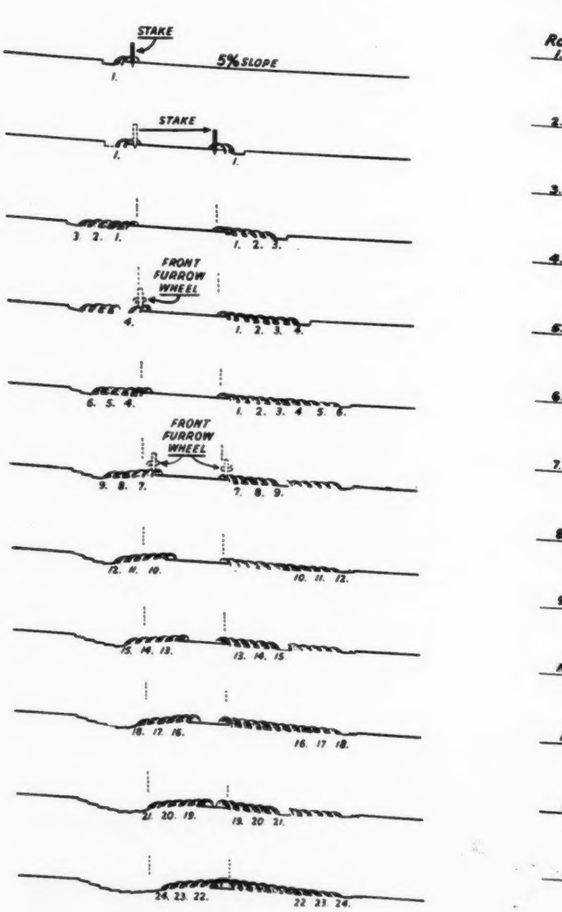
Simplified cross-section scale drawing of the completed terrace built with a moldboard plow

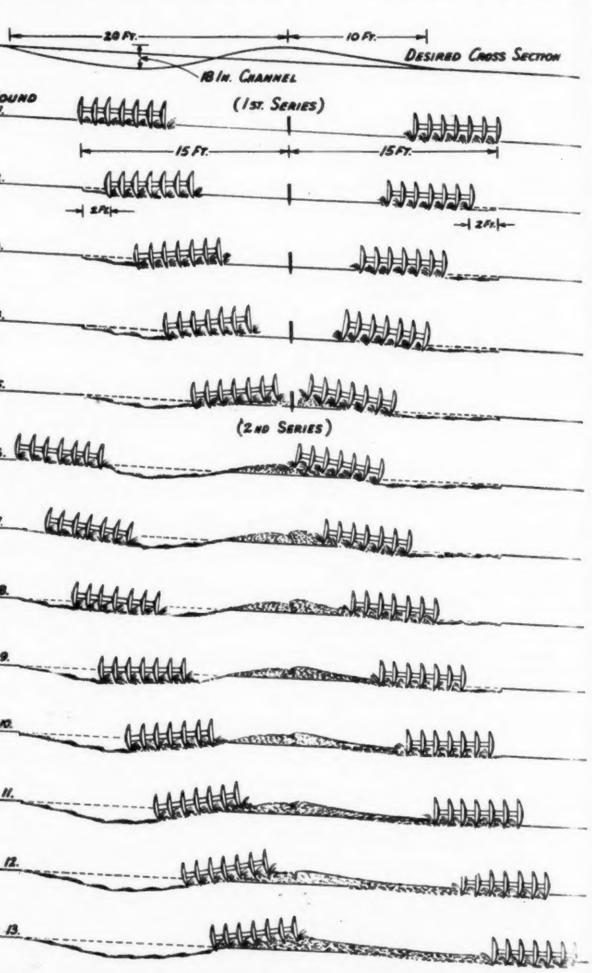
With the island established, a "wave" of 6 furrows is plowed on the channel side of the terrace and a 12-furrow wave plowed on the downhill side. After making the first 6 furrows on the channel side, the plow is moved down to the edge of the island 8 to 12 in closer in than on the first furrow and another 6 furrows made on land previously plowed. Repetition of this procedure gradually moves the wave of soil from the channel to the terrace ridge.

The 12-furrow procedure for the lower side of the terrace is similar, but differs in that the soil is not moved as great a distance onto the island with each movement of the wave of soil. The amount of distance varies with the steepness of the slope.

The development of the "island" and "step-in" systems of terrace building for the two different types of implements promise greater activity and interest on the part of landowners in terrace building. Most landowners are familiar with the equipment and the procedure appears more like a fitting farm operation.

Ways and means of obtaining and perpetuating the terraces after being constructed have been given consideration for some time. Many terraces have been constructed at a considerable expense and later abandoned because of failure to understand and appreciate the importance and necessity of maintenance. The fault may have also been the failure of many of us to (Continued on page 342)





(Left) The round-by-round procedure for building a terrace with a two-bottom, 14-in moldboard plow, starting with a 9-ft island. The number of rounds indicated is usually sufficient to build a 16-ft water channel, 15-in deep, although 27 rounds may be required • (Right) The round-by-round procedure for building a broadbase, drainage type terrace, on a 5 per cent slope, following the "step-in" system for the one-way disk is indicated by this sketch. The "step-in" procedure for the channel side is repeated until the desired depth and width of channel is attained. Speed of travel is an important factor in reducing the number of trips required for the completed terrace

Ground-Water Studies in Relation to Drainage

By J. E. Christiansen

MEMBER A.S.A.E.

THE irrigation census of 1940 indicates that there are now more than 18 million acres of irrigated land in the 11 western states, and that drains have been installed in more than 3 million acres, or 16.3 per cent of this total area. Only 760,304 acres are admittedly in need of additional drainage. One would infer that on about 80 per cent of the irrigated area drainage is relatively unimportant, being taken care of through natural means, or as the result of pumping from wells for irrigation. These census figures indicate that the total area supplied irrigation water wholly or partially from pumped wells now exceeds that in which drains have been installed. In many places in California and Arizona pumping has apparently solved the drainage problem. Many pumps, originally installed for drainage, have later been operated solely to supply water for irrigation. The extensive development of underground water supplies in many irrigated areas has prevented a rise in the water table, and drainage has never been required. Experience in the Sacramento and San Joaquin Valleys of California indicates that wherever the gravity water supply is entirely adequate for crop requirements, and the underground water supplies are not developed because of higher costs, drainage becomes necessary.

Need for Drainage Research. That there is a need for information that will help form a basis for rational design of drainage systems is apparent from the number of partial or complete failures of drainage systems in many places. In the earlier years, drainage practice in the West was patterned after practices developed for the more humid areas. Experience has shown, however, that certain modifications of these practices are necessary in irrigated areas. Because of the higher concentration of salts in the ground water of western soils, the water table must be maintained at a lower depth to prevent harmful concentrations of salts in the surface soil. Primary consideration must be given to the source of the ground water causing the trouble. Often this is at a considerable distance from the area affected. In humid areas, the source is generally rainfall, and the drainage system is designed to remove water at such a rate that the water table can be controlled within certain limits. In these areas, saline conditions are seldom encountered. In irrigated areas, however, the principal source of the excess water may be seepage from canals at higher levels, or from the irrigation of higher lands.

The direction of ground-water flow in the area affected may be principally upward, from aquifers at greater depths, resulting in a rapid accumulation of soluble salts in the surface soil, especially where the irrigation waters contain fairly high concentrations of these salts. This is especially true where the rainfall is relatively light. In alluvial soils, underlain with gravel at appreciable depths, where wells of reasonable capacity might be developed, pumping from wells for drainage is one of the most effective means of controlling the water table. Whether or not open or tile drains will be effective depends not only upon the direction of the ground-water movement, but to a large extent upon the nature of the soil and subsoil to appreciable depths, especially as to its stratification and permeability. More complete information regarding the direction and velocity of ground-water flow, especially near the drains, is required.

In order to study ground-water movement, especially as it is related to drainage design, the U. S. Regional Salinity Laboratory developed a hydraulic probe[1]* with which the vertical component of the hydraulic gradient within the upper 30 or 40 ft of soil can be studied. During the past year the Laboratory has experimented with ground-water piezometers, and it is the purpose of this paper to present the results of some of these studies. Before describing the apparatus and discussing the results of these studies, it may be well to consider some of the fundamentals of ground-water motion.

The pioneer experiments dealing with the flow of water through porous media were those of Henry Darcy[2]. He established the principle which appropriately has come to be known as "Darcy's law". Stated simply, it is: "The flow through a porous medium is directly proportional to the hydraulic gradient, and to the cross-sectional area."

Stated mathematically

$$Q = KA\left(\frac{h_2 - h_1}{l}\right) \qquad [1]$$

where Q is the flow expressed as volume per unit time; K is a constant of proportionality which is dependent upon the permeability of the medium, the viscosity and density of the fluid, and the gravitational constant; A is the cross-section area; and $(h_2 - h_1)/l$ represents the head lost by friction in length l. This equation can also be written

$$q = K\frac{dh}{dl} \qquad [2]$$

where q is the flow per unit area, and dh/dl is the hydraulic gradient. The factor K, generally called the Darcy coefficient of permeability, has the dimensions of velocity, that is, LT^{-1}. Although, as many writers have pointed out, K is not a true coefficient of permeability, inasmuch as it depends also upon the properties of the fluid and upon the earth's gravitational field, it is perhaps the most useful of the different units which have been proposed when dealing with ground-water motion. Corrections for variations in the viscosity of water due to temperature differences can be readily made by introducing the viscosity ratio, μ_s/μ where μ_s is the viscosity of water at a standard temperature (usually 68 F). This correction is approximately 2.5 per cent per degree C (Centigrade), or 1.4 per cent per degree F (Fahrenheit), and is usually negligible in comparison with variations in permeability of soils as found in nature, and as influenced by composition of the ground water.

In order to apply these equations to actual ground-water flow problems one must be able to assign values to three of the four variables involved: flow, permeability, area, and hydraulic gradient. Ordinarily this is not an easy thing to do. Let us consider the flow toward a tile drain. What is the path of a drop of water that enters soil at some distance from the drain? We could perhaps answer this question if we assumed

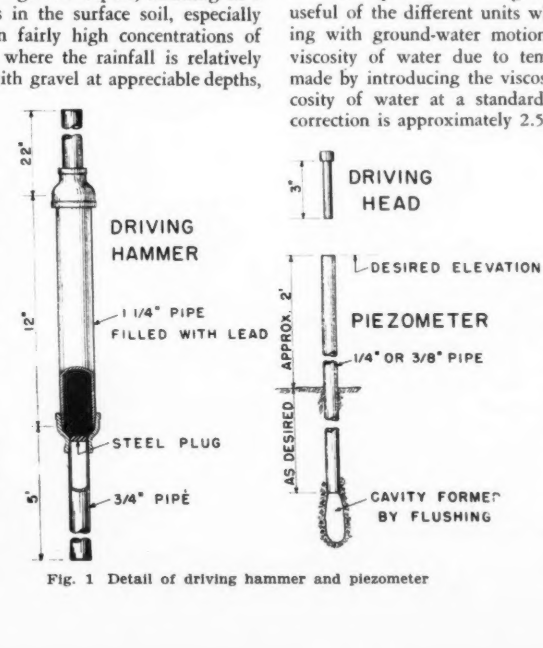


Fig. 1 Detail of driving hammer and piezometer

Paper presented at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers at Logan, Utah, February, 1943. Contribution from the U. S. Regional Salinity Laboratory (BPISAE, ARA), Riverside, Calif., in cooperation with the eleven western states and the Territory of Hawaii.

J. E. CHRISTIANSEN is irrigation and drainage engineer (BPISAE, ARA), U. S. Department of Agriculture.

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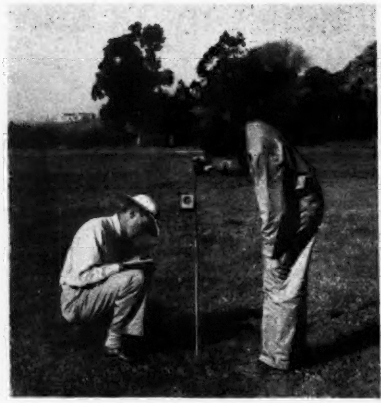
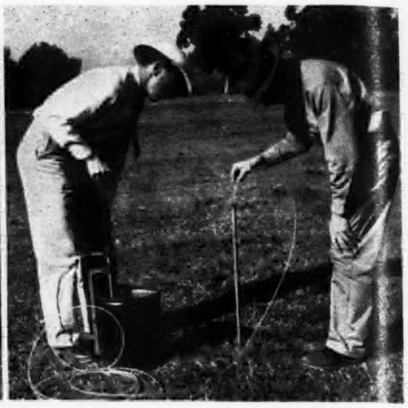
*Superscript numbers indicate the references appended to this article.

Fig. 2 (Left view) Reading the piezometer with an electrical sounder gauge • Fig. 3 (Right view) Flushing the piezometer





that the soil mass was homogeneous and that permeability was everywhere equal. Actually, however, permeability of soils varies through extremely wide ranges, and very few soils are uniform in texture, density, and permeability to any appreciable depth. Many soils have dense highly compacted subsoils of very low permeability. Other soils are underlain with strata of sand or gravel having permeabilities many hundred or even thousands of times greater than the surface soil. Obviously the path of a drop of water and the shape of the equipotential surfaces which are everywhere normal to the direction of flow will depend to a very large extent upon how the permeability of the soil varies with depth.

Ground-water piezometers offer a means of studying the ground-water flow conditions in the field. By means of piezometers one can determine the ground-water potential at any point in the soil mass. These ground-water potentials are everywhere proportional to the hydraulic head, or height to which the water will stand in an open manometer tube. By making simultaneous measurements of the hydraulic head at a number of points in the soil mass on the same vertical plane one can determine the components of the hydraulic gradient, and the direction of flow. By plotting the equipotential lines on a vertical section the "ground-water flow pattern" is obtained. It should be recognized that these equipotential lines are the intersections of the equipotential surfaces and an arbitrary vertical plane and that unless this vertical plane is selected to coincide with the direction of flow the hydraulic gradients as indicated on the flow pattern are not the true gradients but only the components of these gradients along this plane. The term "flow pattern" is not new, having been used by Hubbert[3] in a similar sense.

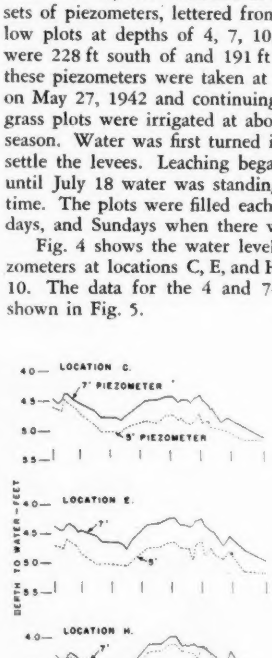
Ground-Water Piezometers. The ground-water piezometers consist of small diameter pipe (both 1/4 and 3/8-in pipe have been used) which is driven into the ground to a definite level with a special hammer (Fig. 1) and in which the static water level is measured with an electrical gauge (Fig. 2). When the piezometers are driven, a plug of soil from 6 to 12 in in length forms in the lower end of the pipe. This is removed by flushing (Fig. 3) which consists of pumping water down to the bottom of the piezometer through 1/4-in plastic tubing. This water flows back up through the annular space between the tubing and wall of the pipe and carries with it soil in suspension. Flushing is continued until a small cavity has been formed below the end of the pipe and the water becomes clear. The plastic tubing is marked for the length of the piezometer, and care is taken not to push the tubing more than 3 or 4 in below the end of the piezometer. After flushing, the water level ordinarily drops very rapidly in the pipes when filled, and reaches an equilibrium level in a few minutes. In some soils of low permeability the water drops very slowly and requires several hours to reach an equilibrium level.

In highly compacted soils, and in those containing fine gravel that cannot pass upward through the annular space during the flushing operation, a rivet is inserted in the end of the piezometer before it is driven. After the pipe has been driven to desired level, the rivet is punched out with a rod before flushing. This eliminates difficulty sometimes encountered in removing the soil plug formed in the end of pipe. In most soils, however, this plug can be removed by flushing in less time than is required to punch out the rivet.

The pipes are started with the 5-ft end of the hammer over the pipe. When driven to such a depth that it strikes the ground, the hammer is inverted and the driving is continued to the proper level. The piezometers are usually left projecting about 2 ft above the ground surface for convenience in reading. Pipe lengths up to 16 ft can be readily driven by a man on a step ladder. In one soil it was possible to push 1/4-in pipe into the ground a distance of 5 or 6 ft before driving was required so that 21-ft pipe lengths could be started. An additional 7-ft length of pipe was coupled to this to form a 28-ft piezometer. When several piezometers are installed in a given location, they are set with the tops level so that corrections to the readings are not required. This is accomplished by using an engineer's level or transit and marking the hammer at the line of sight with a piece of adhesive tape.

Ground-Water Flow Patterns in Imperial Valley. The first studies with these piezometers were made in the Imperial Valley at the Meloland Experiment Station in cooperation with the Irrigation Division of the Soil Conservation Service. Piezometers were installed at two locations, the first in alfalfa and grass plots and the second in fallow plots that were to be leached. These piezometers were installed in sets of four at different depths along lines normal to the tile drains. In the alfalfa and grass plots eight sets, lettered from A to H, were installed at depths of 5, 7, 10, and 13 ft. Six sets of piezometers, lettered from I to N, were installed in the fallow plots at depths of 4, 7, 10, and 13 ft. The piezometers at I were 228 ft south of and 191 ft west of those at H. Readings on these piezometers were taken at intervals of a few days, beginning on May 27, 1942 and continuing until December. The alfalfa and grass plots were irrigated at about weekly intervals throughout the season. Water was first turned into the fallow plots on June 17 to settle the levees. Leaching began on June 22 and from that date until July 18 water was standing on the surface practically all the time. The plots were filled each morning except on Fridays, Saturdays, and Sundays when there was no water in the canal.

Fig. 4 shows the water level fluctuation in the 5 and 7-ft piezometers at locations C, E, and H for the period June 1 to August 10. The data for the 4 and 7-ft piezometers at J, L, and N is shown in Fig. 5.



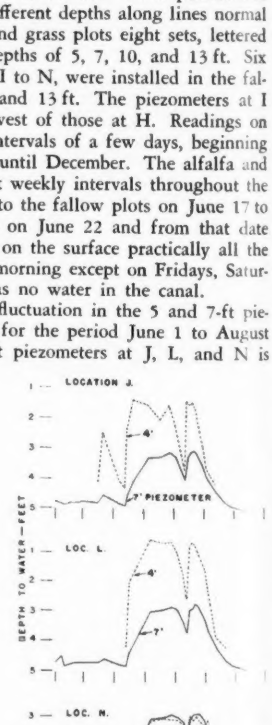


Fig. 4 (Left) Ground-water fluctuations. Alfalfa and grass plots at Meloland • Fig. 5 (Right) Ground-water fluctuations. Leached plots at Meloland

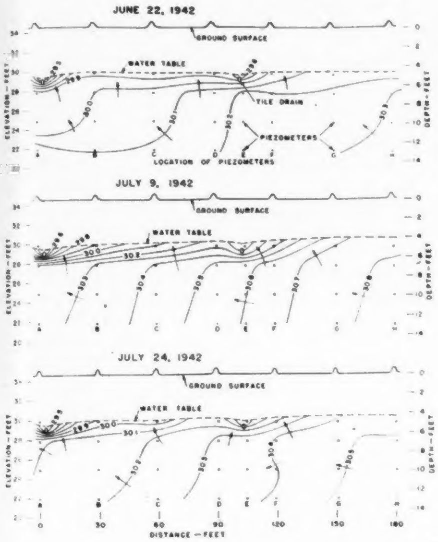


Fig. 6

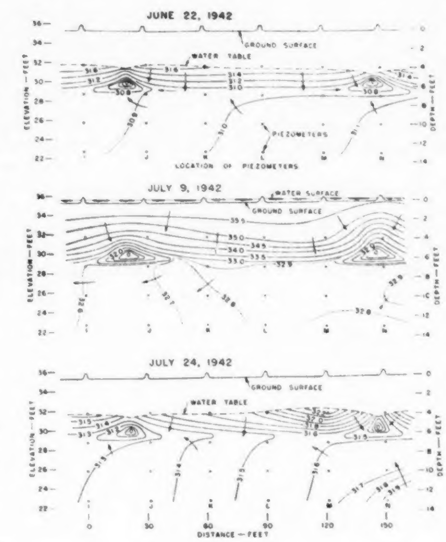


Fig. 7

Fig. 6 (Left) Ground-water flow patterns. Alfalfa and grass plots at Meloland. These patterns represent a vertical section along a line normal to the tile drains which are 5½ ft below the surface and spaced 100 ft apart. The solid lines show the traces of the intersection of the equipotential surfaces and this vertical plane. The direction of ground-water flow as indicated by the arrows is normal to these equipotential surfaces and in the direction of decreasing potentials, which are shown as the elevation at which the water level stands in the piezometers. Water is apparently moving upward from the saturated zone to partly supply water removed by transpiration from the root zone above • Fig. 7 (Right) Ground-water flow patterns. Leached plots at Meloland. These patterns represent conditions where no crop is present, and where excess water has been applied and is escaping from the area. The movement of water above the sand stratum at the 6-ft depth is essentially downward. Note that on July 24, six days after leaching was discontinued, the water table dropped to approximately its normal position

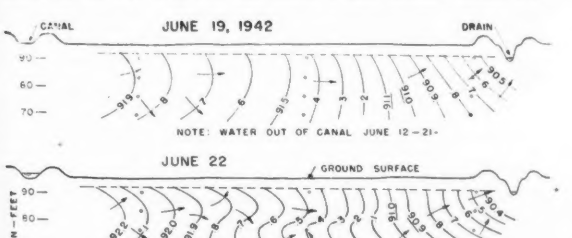
The leaching caused a sudden rise in the piezometric levels at J, L, and N and a slight rise at C, E, and H, although these plots were more than 300 ft away. Note that the direction of flow is up at C, E, and H, and down at J and L, and that there is little gradient at N. The water levels in the 10 and 13-ft piezometers were essentially the same as in the 7-ft piezometers at all locations and were therefore not shown. An exploration with a soil auger at a later date indicated a stratum of very fine sand approximately 6 ft below the surface, the overlying soil being a clay. Figs. 6 and 7 show the ground-water flow patterns at each location on three different dates. The first date, June 22, was at the beginning of the leaching period, the second date, July 9, was during the leaching period, and the last date, July 24, was shortly after the leaching period. The effect of the leaching is evident in the grass and alfalfa plots by the increased gradient from H to A, and the rise in the water table. It appears that some of the ground water moving out from the leached area passes underneath a number of tile drain lines. The sand stratum mentioned is from 6 in to a foot below the tile lines.

These ground-water flow patterns show that at this location the water movement in the clay soil above the sand stratum is essentially vertical and that the horizontal movement occurs principally in the sand stratum. Experience in Imperial Valley indicates that in some locations tile lines are not effective in controlling the water table, while in other places they are. It is probable that the permeability of the clay is so low that unless a sand stratum occurs within a reasonable depth, water movement toward the drains is too slow to be effective.

These patterns also indicate the difficulty that would be encountered in trying to predict the flow pattern by analytical methods. To secure undisturbed soil samples of these highly stratified soils which can be used for laboratory determinations of permeability is extremely difficult. To set up equations which will take into account the variations in permeability of the different strata is practically impossible. Equations based on the assumption that the soil is homogeneous are often misleading.

Ground-Water Flow Patterns at Delta, Utah. At Delta, Utah, piezometers have been used in cooperative work with Dr. O. W. Israelsen of the Utah Agricultural Experiment Station and the Division of Irrigation, Soil Conservation Service. They have been employed to determine general ground-water flow patterns, and to determine the position and slope of the water table, replacing 2-in open wells formerly used. Fig. 8 shows the ground-water flow pattern between a canal and an open drain. This canal had previously been lined with clay to reduce seepage losses. Before lining, water was reported to have stood frequently on the soil surface near the canal. Unfortunately no measurements of the slope of the water table at this location were made at that time.

The piezometers were installed at depths of 5, 12, 19, and 26 ft during a period when water was temporarily out of the canal. As soon as water was placed in the canal the water table began to rise, and as is indicated by the ground-water pattern for June 22,



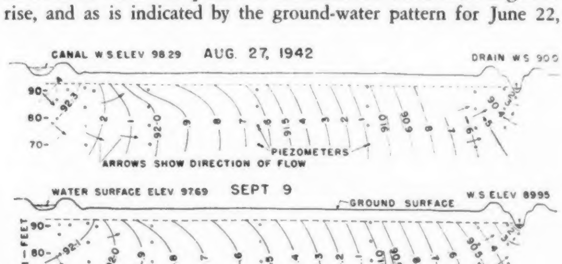


Fig. 8 (Left) Ground-water flow patterns at Melville east canal, Station 25 + 00. Note the change in the flow pattern on June 22, shortly after the water was placed in the canal • Fig. 9 (Right) Ground-water flow patterns at Melville east canal, Station 20 + 00

the greatest change occurred in the readings on the 12-ft piezometers indicating a more permeable material and a more rapid velocity of ground water at this depth. On June 29, the pattern had resumed its original appearance, but the water table was about 0.5 ft higher near the drain and 1 ft higher near the canal. In this location it appears that horizontal flow occurs through an appreciable depth of soil, although it is probably most rapid at about the 12-ft level.

To secure more complete data, especially near the canal and drain, and to eliminate some of the difficulties experienced at this location, a more desirable location was selected 500 ft upstream on the same canal. Here 7 sets of piezometers were installed between the canal and the drain. The flow patterns on three different dates are shown in Fig. 9. Between August 27 and September 18 the water level dropped 1.21 ft in the canal, and the water table near the canal dropped about 0.8 ft, causing a slight change in the flow pattern. Unfortunately, it was necessary to discontinue readings on September 18 before water was turned out of the canal, and before there was any appreciable change in the flow pattern.

Studies at Riverside. In the studies at Riverside it was decided to use piezometers in connection with a small well, to which water could be added or from which it could be pumped so that the actual flow of water, Q, could be measured, and the permeability, K, computed from Darcy's law. The purpose of these studies is to devise a practical field method of measuring the permeability of the soil in place which can be used as a basis for the selection of a method of drainage and the design of drainage systems. This method of attack is essentially a modification of Thiem's method which has been successfully used by Wenzel[4] and by Israelsen and Morgan[5] for determining the permeability of water-bearing strata. The principle difference is that the flow in which we are interested is that through shallow strata, and the actual flow pattern was determined instead of just the slope of the water table toward the well as indicated by observation wells. Tests were carried out at two locations, one where water was added to a well and another where it was pumped from a well. The results of these tests have not been completely analyzed, but this method of attack appears promising.

Additional studies have been made of a local drainage problem where it was found that water was moving into the area through a sand strata about 8 ft below the surface, and where an immediate change in the ground-water flow pattern was produced by tapping this stratum with auger holes bored in the bottom of an open drain.

SUMMARY

The irrigation and drainage census show that drainage works have been constructed on about 3 million acres, and that a like area is irrigated wholly or partially by pumping from wells, which may eliminate the necessity for other drainage. Nearly a million additional acres are admittedly in need of drainage.

Research at the U. S. Regional Salinity Laboratory is directed toward studies that have general application to the salinity problem, including development of methods and equipment that can be used by the respective states in the solution of their specific problems.

During the past year piezometers have been developed and used for studying the flow of ground water. They have proved very satisfactory for determining the general flow pattern, and they appear promising as an aid in determining actual permeabilities of soil strata.

Drainage design has been largely empirical. There is a real need for data on ground-water flow patterns and soil permeability which can serve as a basis for a rational design. With such information it should be possible to select the most practical methods of drainage, to improve drainage design, and thereby drain soils with minimum expense, thus preventing both unfavorable moisture conditions and increase of salinity.

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Building and Maintaining Terraces with Ordinary Farm Machinery

(Continued from page 338)

provide suggested systems of maintenance. It is quite obvious that the same procedures followed in terrace construction can also be used in terrace maintenance, or if this appears undesirable or unnecessary, a standard backfurrowing and deadfurrowing maintenance procedure as worked out for the moldboard plow and various types of disk plows can be followed. To be able to use equipment whose functions and facilities are well known to the farmer for both terrace building and maintenance offers further assurance of greater interest and activity in terracing.

It is not known at the time of this writing whether the standard type disk plow has been used for terracing following either of the systems described above. It is believed that best results would probably be obtained by following the "island" system, although the "step-in" system with the standard disk plow might be followed successfully.

The systems briefly described here fit the regions and the ideal type of terrace in which the tools are found. The moldboard plow following the "island" system is adapted to all three types of terraces in soils that are moist and that scour well. The small 4 to 6-ft one-way plows which are becoming quite common in the southeastern states are best adapted to the building of the smaller terraces recommended for that region. At the same time, the larger 8 to 10-ft one-way disk plows of the Great Plains are best adapted to the building of the broader, absorptive type terraces.

The one-way disk plow does its best terracing work under relatively dry soil conditions and has been said to do satisfactory work in hard ground that could not be plowed with a moldboard. There are many regions, of course, where both types of plows are used and where either system could be employed.

An outstanding objection to previous methods of plowing terraces or building them with ordinary farm tools has been the resulting V-shaped water channel and the formation of a ridge or mound of earth *above* the water channel. This ridge was objectionable because water from heavy rains tended to collect back of it instead of flowing readily into the water channel. In heavy rains the water will eventually pour into the channel in rivulets and form small gullies along the sides. Throwing the soil uphill from the channel also resulted in seemingly wasted effort because this earth is soon washed back into the bottom of the water channel. Why not devote this effort to moving all of the soil from the channel down hill to build a higher terrace ridge and thus increase channel capacity?

The "step-in" and "island" systems both require that *all* the earth from the terrace channel be thrown downhill to build up the ridge or earth mound. The return trips of the plow following both systems are used to build up the lower base of the ridge, and the procedure recommended — if carefully followed — will avoid the formation of an objectionable water channel below the ridge for the drainage type terrace. A slight variation in the procedure will permit the formation of a small water channel below the ridge, as prescribed for the Great Plains absorptive type terrace.

Bluegrass Terrace Outlet Channels

(Continued from page 336)

14 Observed velocities varied from 2.2 fps for a hydraulic radius of 0.52 and grass density of 3.1 on a 1 per cent slope, to 14.7 fps for a hydraulic radius of 0.60 and a grass density of 2.4 on a 20 per cent slope.

15 One-year-old bluegrass was inferior to one-year-old timothy and redtop in preventing scour, whereas two-year-old bluegrass was superior to timothy and redtop. There was little difference in protection against scour between one and two-year-old mixed timothy and redtop sod.

16 One-year-old bluegrass allowed severe scour for velocities above 3 fps, whereas the scour was negligible for two-year-old bluegrass for a velocity of about 7 fps.

Farm Freezer Analysis

By C. W. DuBois

FOR THE past several years the author has carried on experimental work in connection with preserving foods by freezing for home use in lockers and individual cabinets. This work involved studies dealing with (1) varietal adaptation and maturity of fruits and vegetables for the process; (2) preparation and handling all products including meats, poultry, vegetables, and fruits to maintain their original high quality; (3) economical and efficient packaging materials for protecting the food against contamination, desiccation, oxidation, and color changes; (4) rates and methods of freezing as it affects the quality, and (5) temperature and conditions of storage as they affect the quality of frozen products. There are still a number of unsolved problems, and projects have been undertaken at Louisiana Agricultural Experiment Station along the same lines.

A number of factors in the freezing of foods are interdependent one on the other, if quality and food value are to be maintained. Should one or several conditions be adverse they may cause spoilage and heavy loss or permit undesirable physical and chemical changes. Engineers must consider these factors as well as engineering phases in designing farm freezing equipment. There should be coordination of engineering with food technology.

Early in 1942 a survey of farm freezer users was made in New York state. The purpose was to obtain first-hand information on the operation, reception, and other data. The material desired included (1) reception of present designs; (2) size owned; (3) number in family using cabinet; (4) whether or not it was found adequate; (5) practicability of cabinet; (6) quantities of vegetables, fruits, meats, and other foods handled through the cabinet during the year; (7) cost of operation; (8) suggestive changes that might be made in cabinets; (9) problems encountered during use; (10) cabinet type preference; (11) whether or not professional butchering services were desired and used; (12) whether or not the cabinet was desired to be a part of the kitchen equipment. The results of the survey were somewhat disappointing in that most users had had such limited experience with their equipment. What most users had done could not be considered general practice because the first season's use was chiefly a trial experience. Some of the observations are interesting, but they should not be considered conclusive.

Until March 1, 1942, there were known to be sixty-six freezing and storage cabinets operated on New York state farms. During the spring and summer months that followed, numerous such cabinets and new and used ice cream cabinets were purchased by farmers for freezers.

Twenty farmer owners of freezing cabinets were visited in February, 1942. The size of the cabinets owned averaged 24 cubic feet with an average of five persons using each cabinet. Most of the cabinets were kept in the cellar, but occasionally one was found in the garage, the summer kitchen, or another room near the kitchen. Only two owners kept detailed records of the foods frozen, stored, and used from their cabinets. Several had meters loaned to them by their electric company, but only two kept accurate records of the cost of electricity. The one question which is invariably asked is, How much does it cost to operate a home cabinet? There is no definite answer because there are too many variables to consider. The power consumption is affected by the section of country in which the cabinet is operated; the location of the cabinet on the premises; the make, type, and size; the ambient temperatures; the thickness and types of insulation used; the amount of food frozen and stored; the initial temperature of the food placed in the cabinet to freeze; the number of times the cabinet is opened; the adjustment of the controls; the temperature maintained; the amount of frost on the evaporator; and type of evaporator.

Of the farmers surveyed all were satisfied that the cost of operation was not excessive. Of those two keeping records, one owner reported that it cost $16.50 per year to operate a cabinet of 15 cubic feet in size kept in a cool cellar. The other owner indicated that it cost $25.00 per year for current for his 24 cubic foot cabinet, also kept in a cool cellar. The cost is affected by the owner's total load and the electric company's rate system. In the laboratory the average power consumption of two different makes of cabinets, each with 24 cubic feet of capacity, equipped with air-cooled, ½-hp compressors, kept in a room which averaged 75 F the year around, was 2012 kw-hr per year.

In Louisiana there are indications that the power consumption would be much higher with the same type of cabinet than that indicated above, because of higher ambient temperatures for cabinet and compressor and higher initial temperature of foods placed in the freezer. There are no cool cellars.

Three out of twenty farmers had used their cabinet longer than 3 years, two from 2 to 3 years, two from 1 to 2 years. The remainder had theirs from one month to a year, of which the greater proportion were purchased in the fall and winter of 1941-42. In general, most of the users were thoroughly satisfied with the type and design of their cabinet, of which all but one were top-opening, chest type cabinets. Occasionally an owner suggested that some simple method which would aid in locating desired packages easily was desirable. None felt that the freezer should be a part of the kitchen equipment. Nevertheless with longer experience in freezing foods at home their desires may change. Two farms had two cabinets each. At first one cabinet was purchased; then the second was added when the size of the original was found inadequate. Two users also rented additional locker space at a locker plant. One owner had a 32 cubic foot cabinet and rented two lockers. The other user with a 15 cubic foot cabinet rented one large-sized locker. This would indicate that cabinet size should be carefully considered.

All but two persons indicated they wished to cut and wrap their own meat rather than have some butcher shop or locker plant do it for them at a nominal fee. However, if the services of cutting and wrapping are available near at hand, there are indications that some owners would avail themselves of these services rather than do it themselves.

In one case an owner operated a cabinet in which one section (8 cu ft) was designed to be used as a household refrigerator while the other section (16 cu ft) was maintained at 0 F for frozen food storage. The household refrigerator section was not refrigerated by direct expansion, but it was cooled by means of heat transfer from this section to the 0 F section. When the heat transfer was normal and average room temperatures occurred, the cabinet operated satisfactorily, but when the temperature of the air surrounding the cabinet had cooled down to a point where the heat leakage into the 0 F section from the 32-36 F section was greater than the heat leakage from the outside air into the 32-36 F section, all the food became frozen solidly. Unless this type of cabinet is kept under properly controlled outside temperatures it does not work out satisfactorily.

None of the users reported any experiences of failure in operation of freezing equipment. Breakdowns are not expected from new equipment, but there may be occasional power line failures. Other electric failures than those caused by snow, sleet, or wind storms usually are not prolonged enough to cause trouble unless they are of frequent occurrence. The rate of temperature rise in a cabinet, in case of power failure, is affected by the amount of food in storage, type of food, outside temperature, and insulation thickness. Cabinets under laboratory conditions, without any load, usually rise from 0 to 20 F in from 15 to 20 hours. When loaded with a considerable quantity of meats and with fruits and vegetables, the time is at least doubled. Heavily sugared or syruped foods defrost first, followed by meats and vegetables somewhat later.

The argument presented against the top opening well type cabinet is that desired packages are often difficult to locate and a great number of articles must be removed to find those wanted. The manufacturers of commercial dispensing frozen food cabinets used in stores have worked on this problem for years in an effort to produce a cabinet in which the foods can be found easily and quickly.

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It has not been satisfactorily solved as yet and the problem seems more difficult where irregular-shaped packages are handled. The problem is partially solved by systematic arrangement of packages in the cabinet. A side-opening cabinet at first analysis seems to be the solution to the problem of locating food easily. However, the problem is almost as serious with this type as with the well type cabinet. It is just about as difficult to locate a package of beans on the bottom of a stack of several packages in the back corner as it is to find a package on the bottom in the back corner of a well cabinet. In addition, there are other rather serious problems with the side opening cabinet: (1) Each time the cabinet door is opened the cold air literally falls from the cabinet, resulting in temperature fluctuations and somewhat greater power of consumption in restoring the proper temperature conditions; (2) frosting up of the evaporator surface is greater; and (3) freezing of ice around the door seals, resulting in the sticking of the door. Perhaps with some special features and improvements these disadvantages could for the most part be eliminated.

The idea of individual farm freezers began to develop early in 1938, but marked interest and purchases occurred in 1941-42. Expansion in this equipment was abruptly curtailed by wartime restrictions late in 1942. However, its popularity has continued to grow and there seems little question that this field will expand beyond expectations at the close of the war. Without a doubt many manufacturers of refrigeration equipment will enter the field of manufacturing such cabinets at that time. There probably will be as many ideas on designing such cabinets as there will be manufacturers. It must be remembered, however, a cabinet may be a work of engineering perfection, but if the use to which it is to be subjected is not considered thoroughly, it may prove unsatisfactory.

What size should a cabinet be? What should it do? Can it be a combination of a variety of facilities, or should it be equipment made for a particular specialized task? Should its delivery price receive more consideration than results obtained from it? What features should it have for obtaining the best practical results? What load should it handle in a given time? And many other questions will need to be answered for production of a successful cabinet.

In some of the early cabinets made in 1938, brine tanks were used because of the eutectic advantages of the brine. The idea was a revival of the then outmoded idea used somewhat earlier with ice cream cabinets. The brine tank, even though it had some advantages, was soon abandoned because of the reduced efficiency, increased weight of cabinet, early leaks in the tank as a result of corrosion from the brine, and the cost of building the tank.

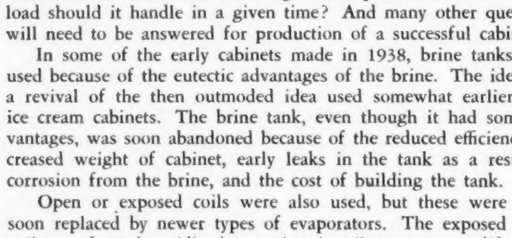
Open or exposed coils were also used, but these were soon replaced by newer types of evaporators. The exposed coil type frosted rapidly due to the air-coil temperature differential. Defrosting was required frequently if a low temperature was to be maintained in the storage and if the compressor was to operate most efficiently. The defrosting of both exposed and finned coils was difficult to carry out because all the food had to be removed and heat added so as to melt away the accumulated frost.

Most of the later cabinets either were made with smooth surface evaporator plates or by building the coils in the walls, so that there were unobstructed smooth surfaces on the interior of the cabinet from which the frost could easily be scraped. Frosting of such surfaces was less serious due to lower evaporator-air temperature differential.

It might be well to point out that the relative humidity in farm cabinets is lower than most large storage rooms, ranging from 10 to 50 per cent. The exposed tubing types usually run somewhat lower in humidity than the flat surface evaporator types. With a low relative humidity it is evident that products must be well protected if early oxidation and desiccation are to be prevented. Products poorly protected cause the evaporator to frost up more readily.

As a result of some experiences in 1939, it was found that a cabinet could be built on a farm if all the principles of insulation, refrigeration, and mechanics of connecting a refrigeration system were understood. Nevertheless, it seems unlikely that most farmers have the tools and sufficient training to build cabinets for themselves any more than they would attempt to build a tractor or a radio. Since there was little, if any, saving by constructing a cabinet on a farm and since the problems were such that a farmer was apt to have more difficulties than he could anticipate, the author and associates concluded that they could better aid farm people by working with commercial manufacturers in producing a cabinet that would be practical.

Most of the cabinets constructed in the past have had two compartments, one for freezing foods and the other for storage of foods after they have been frozen. The two compartments furnished good conditions for freezing and permitted maintaining relatively uniform temperature in storage. Most of these cabinets used fans which were mounted in the freezing section so as to speed up the freezing of the food by circulating the cold air around the packages. In experiments the addition of air circulation over packages at a maintained temperature decreased the freezing time by about 50 per cent (See Figs. 1 and 2). In a farm cabinet this freezing rate would be affected by the load, evaporator surface, and compressor capacity. A load greater than the capacity of the system to absorb heat would reduce the rate of freezing in proportion to the amount of overload. The freezing rate of food is also affected by placement and arrangement of the packages. Except when placed on a refrigerated surface with packages one layer thick, products would freeze much faster with free passage of air around (Continued on page 346)



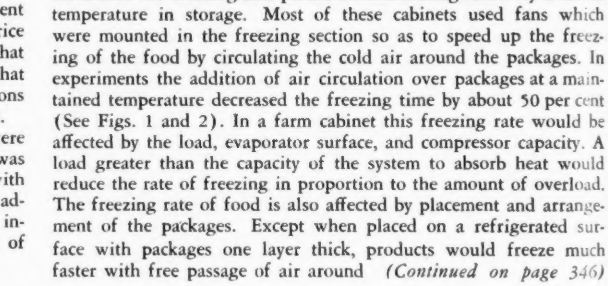


Fig. 1 (Left) Differences in freezing rates of three samples, each weighing 3½ lb and of from 3¼ to 3½ in thick. Cabinet 1 with two compartments with coils built in the wall was powered by a ½-hp unit. There was a fan mounted in the back of the freezing compartment in a duct opening at the bottom and the fan opening at the top. The air was drawn through the duct and was forced out at the bottom. Cabinet 2 had a freezing compartment around which was a metal jacket. The jacket, refrigerated by coils, contained eutectic brine. The roasts were placed in the cylinder against the brine wall. Cabinet 3 was much like Cabinet 1 in design except plate evaporations were used. The roasts were placed on shelves and frozen by air circulation. The greater length of time required to freeze the samples in Cabinet 3 was thought to be a result of a smaller fan in the compartment, moving less air over the products • Fig. 2 (Right) Temperature drop curves taken in the center of roasts showing difference due to freezing conditions with sizable loads. Curve A shows the temperature drop in a roast frozen in a locker plant freezer on horizontal plates. The total freezer load was 120 lb. The system possessed adequate capacity. Curve A' shows the temperature of the air over the load being frozen. Curve B shows the temperature drop in beef roasts placed on a horizontal plate in a one compartment farm cabinet, operated by a ½-hp air-cooled compressor accompanied by a 70-lb load of beef. Curve B' shows air temperature over samples represented by the B curve. Curve C_1 shows the temperature drop in roasts of beef placed against a vertical plate evaporator in another farm cabinet powered by a ½-hp compressor. The load totaled 90 lb of meat. Curve C_2 shows the temperature drop of a roast frozen in the same cabinet but with no air circulation, and not in contact with the evaporator. Curve C' illustrates the air temperature in the cabinet around samples being frozen, shown by curves C_1 and C_2.

The New Reclamation Era in Venezuela

By W. L. Powers

MEMBER A.S.A.E.

SOIL and water are two great fundamental, renewable resources. Petroleum, rare minerals, and forests are expendable and may be depleted, yet the increasing population must be fed.

Soil has supported and must continue to support all life. Water is needed almost daily by all forms of life. When soil and water are united by irrigation, they give high productive value to what was formerly arid waste land. The nations that failed to conserve soil and water resources no longer exist. The progressive countries are conserving and utilizing these basic resources. Reclamation is the watering of droughty land to enable it to increase production or to insure heavy production with regularity. The economic irrigation requirement is that amount of water which will give the highest net profit per unit of water and land, all costs considered indefinitely. The first fundamental principle of irrigation is that a rich well-balanced soil solution will render sufficient the least amount of water per unit of crop.

Venezuela now ranks third among the oil-producing countries of the world and enjoys the revenue from this; yet her officials look to the future and have under way a new reclamation era. The Direccion de Obras de Riego in the Ministry of Public Works is in charge. Eng. J. B. Bond, former manager of the Boise, Idaho, project of the USDI Reclamation Bureau, has served intermittently the past three years as consulting engineer. The author is here, on leave, to make land irrigability classifications and selections, and six projects have been studied the past eight months.

When the Spanish explorers established the first settlements on the American continent at Cumana' in 1520 and at Coro in 1529, they found the natives using water for irrigation, and they extended the practice. The diversion points and canal lines for some of the new irrigation projects are near the sites or follow closely and extend lines of the colonial ditches, some of which have continued operation until recent times. Floods and revolutions interfered with some colonial reclamation works and until the last six years little expansion had occurred for more than a century.

Recently constructed projects now in operation include:

San Carlos	5,000	hectares
Los Montones	550	"
Guanare	1,500	"
Suata	3,800	"
Tuy	1,200	"
Total	12,050	"

The diversion and storage works for the Suata were recently dedicated, and the distribution canal is nearing completion to serve an area around Cagua near Maracay. Construction is now underway for the diversion works to supply water to some 2,400 hectares on the lower Manzanares River near Cumana'.

Engineering, soil, agricultural, and economic studies are well underway for several new projects named for the stream or storage site that is utilized, as follows:

Manzanares, near Cumana'	2,500	hectares
Guataparo, near Valencia	2,500	"
Neveri, near Barcelona	6,245	"
Taiguaiguai, near Maracay	8,000	"
Motatan, west of Lake Maracaibo	25,000	"
Caujarao, near Coro	1,800	"
Barlovento	80,000	"
Carora	7,500	"
Torito, west of Valencia	2,000	"
El Palmar, west of Maracaibo	40,000	"
Total	175,545	"

These projects are generally situated close to centers of population and the lands included are largely recent alluvial soils of smooth to gently undulating topography, of good depth, water capacity, and fertility, and with good to fair surface and internal drainage. The soils near Comana' and Coro are arid, unbleached, and calcareous. Those near Valencia and Maracay, developed under approximately one meter annual rainfall unevenly distributed, range from moderately acid to definitely boric with few faintly alkaline spots encountered.

Some of the projects, as Motatan, Barcelona, and Maracay, are multipurpose with flood control and hydroelectric power features. Economic opportunities will be created on the project farms and in related agricultural industries for several thousand families.

Some recent water laws increase protection for public and private investments in reclamation in Venezuela. The country has followed the common law doctrine of riparian rights for privately owned lands and permits use by stream bank owners for themselves or others, sharing the use with other riparian owners without injuring them.

The 1942 law provides for granting concessions for use of water occurring on pubic lands and limits concessions to use to a maximum of 60 years with the provision that works constructed are to revert to the government upon termination of the concession. Adjudication and administration is by a judge to be designated, upon petition of the water users on the stream. Ground water appropriation is permitted within the apparent safe annual yield. Wells are not to be constructed within K O .4 of those of any city aqueduct which may need ground water. There is a provision for capping artesian wells. Further legislation that appears to be needed and the proposals being considered are as follows:

1 Creation of a federal water commission to be composed of the four cabinet ministers designated to issue water concessions in the Ley Forestal y de Aguas, namely, the ministers of agricultura y cria, fomento, relaciones interiores, and public works, with a secretary and technical advisor, perhaps the Direccion de Obras de Riego.

2 Establish one central office of records for all water rights and concessions. Perhaps this could best be the secretary of the commission.

3 Authorize the commission, through its Secretary, to withdraw waters needed for proposed projects pending feasibility surveys, to protect federal investments in surveys or construction.

4 To promote development, declare that, subject to existing rights, all waters of the nation belong to the public and are open to appropriation for beneficial use, provided that riparian claimants be given a reasonable time at the discretion of the federal water commission, in which to complete application of waters claimed.

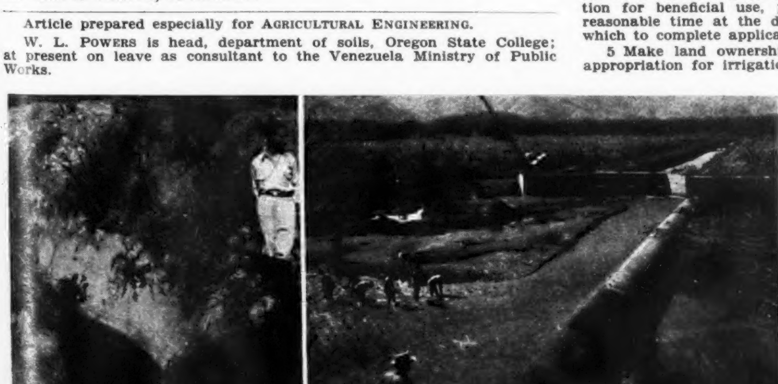
5 Make land ownership or possession a requirement to perfect an appropriation for irrigation, and make water rights appurtenant to the land, to avoid speculation.

6 Require appraisal of private holdings over 40 hectares in area and within projects and agreement by owners, that in case of sales at advanced prices later, one-half tse increase above water charges is to be credited to the government, to reduce the construction charge.

7 Outline a definite procedure for application for a concession or preliminary permit to initiate an appropriation according to forms and maps to be specified by the

Article prepared especially for AGRICULTURAL ENGINEERING.

W. L. POWERS is head, department of soils, Oregon State College; at present on leave as consultant to the Venezuela Ministry of Public Works.



These two views show (left) an old Spanish-colonial ditch near Valencia, Venezuela, with steep sides, heavy spoil bank, and no berm, and (right) a dam recently dedicated on Rio Aragna which diverts water to the Suata reservoir and project

secretary of the federal water commission, and authorize issuance of a water right certificate upon making proof of completion of the appropriation, and provide a schedule of stamps or fees for permits for different uses.

8 Make all claimants on a stream parties to a hearing for determination of existing water rights upon petition of the water users, and provide for a fact-finding survey of ditch capacities or stream flow and irrigated areas by the secretary of the commission.

9 Provide for appointment of water masters by the secretary of the federal water commission, upon adjudicated streams upon petition of the water users, to administer water deliveries and prevent waste, and fix qualifications, duties, and remuneration of these. Authorize the secretary to require headgates and measuring devices.

10 Provide a power policy with net receipts from by-product hydroelectric power incident to irrigation construction, applied first to reduction and retirement of construction costs, then one-half to reduction of operation and maintenance charges and the other half to the federal reclamation fund to be used for feasibility surveys and investigations.

11 Provide for a determination of benefits by the secretary of the commission, on multiple-purpose projects for apportionment of costs to irrigation, hydroelectric power, flood and erosion control, navigation and sanitary drainage, or other purposes, to be established by resolution of the commission.

12 Provide for (non-profit irrigation cooperatives or conservancy districts) with right of eminent domain and limited right of stock, assessment, and require that all plans and specifications and contracts for construction of irrigation or drainage works involving an investment of Bs. 10,000 or more, or dams 3 meters or more in height, be submitted to the secretary of the federal water commission for approval before execution or construction.

A wide variety of crops can be produced on these projects. Double cropping may be practiced with irrigation in the all-year growing climate. Basic food crops that may be grown include corn, beans, yuca, bananas, and sugar cane. Deficiency crops and agricultural products now imported can be produced such as rice, cotton, oil plants, needed vegetables, and tropical fruits, as well as dairy products and meats. As these projects come into production, it should tend to reduce the cost of basic foods, improve human nutrition, and release foodstuffs now imported for the defense of democracies or for general postwar needs. It should improve the quality of farm products and increase the productive area of the nation permanently. Farming with irrigation may be intensive so that the smallest area is sufficient for the support of a man, a condition that favors peace and security.

Farm Freezer Analysis

(Continued from page 344)

than where they are piled in the cabinet solidly. Some cabinets have been equipped with shelves upon which the packages could be spread out so that they could dissipate heat rapidly. Shelves have been found to be advantageous in the freezing compartment where air blast is used, but they have little or no value in the storage compartment. A one-compartment cabinet in general has not been desirable because of the excessive fluctuations in temperatures which usually occur each time foods are introduced to freeze. There is danger of overloading the compressor by the user filling the compartment with warm food. There is also the danger of the user mixing quantities of warm foods with foods already frozen.

On the other hand, the cost of a two-section cabinet may be greater because of the extra labor and materials necessary to provide adequate evaporator surface in both compartments. There are possibilities that a one-compartment cabinet may be successful if some provision is made where foods may be sharp frozen without affecting those foods already in storage.

Rapid freezing of foods has two distinct and important roles: (1) It prevents losses, by rapid cooling and subsequent freezing, thus preventing bacterial growth and spoilage, and (2) it prevents excessive leakage of the essential juices upon thawing and cooking.

The value of proper, uniform storage temperatures for holding frozen foods is well established. In some work reported by our laboratories in 1940 and 1942 it was shown that in general the fat of meats becomes rancid in from two to three months when stored at 15 F, from 4 to 5 months at +10 F, and that most meats may be kept in good condition for one year at 0 F.

As reported in 1939 and 1942, the packaging materials, adapted to low-temperature conditions, are important for protecting foods against desiccation and inhibiting certain oxidative changes occurring at the surface as a result of desiccation and exposure to air. Although wax paper is used in considerable quantities, it is not very satisfactory for packaging foods for farm freezers.

Recently it was reported, as a result of our work, that salt affects the keeping of ground pork and beef. Salt added in the samples caused the fat to become rancid sooner than samples without this ingredient. Simultaneous to rancidification of the fat the color of the sample, both fat and lean, fades materially. Pepper, sage, mace, or ginger had some slight protective action. The protective action was slightly more pronounced with mace or ginger than with pepper or sage.

Rapid cooling and freezing is particularly important in the South where the temperature of many vegetables and other foods is from 75-90 F when placed in the freezer, because in most cases it is impractical to precool them. This condition often occurs in the summer in the North on many farms. At such temperatures food may easily spoil as a result of bacterial growth, unless the temperature at the center of a package is reduced rapidly.

During the period since 1938 there has been some trend toward reducing the compressor size in relation to cabinet volume. It is felt that the compressor should be large enough to handle adequately the maximum leakage and service loads as well as the greatest amount of high latent heat value of food which the freezing compartment will accommodate. The compressor then would be sufficient in size to handle a peak load, thereby eliminating danger of overloading the equipment with warm foods which might spoil before cooling sufficiently at the center to retard bacterial action.

The size of cabinet required for a given family is an open question, because there are many factors which affect the size requirements. It is the question least easily answered yet it is as important as any of the other considerations. Factors such as the number in the family, the section of country, habits of eating and preserving, the selling price of the cabinet, the rapidity of turnover of food in the cabinet, the amount of food processed at home, whether or not locker plant facilities are available, and the extent to which these facilities are used, must all be considered. It has been suggested that a cabinet of 8 cu ft capacity (approximately 300 lb) will be most popular. For urban and suburban families, and farm families who use community locker facilities, this size may be adequate. A larger cabinet, however, seems necessary for farm families who produce and preserve all of their own food supply of meat, poultry, fruits, and vegetables by freezing. Based on the evidence, one ranging from 18 cu ft (approximately 700 lb) to 30 cu ft in capacity (approximately 1200 lb) would be required. From 35 to 45 lb of food can be stored in 1 cu ft of space.

In some quarters a great deal of emphasis has been placed on selling price of a farm cabinet. It might be pointed out, if price is the main object when designing and building the farm freezing and storage cabinet, sacrifices usually must be made. Such compromises may be made by a reduction in quality or thickness of insulation, reduction in size and capacity of condensing unit, elimination of some controls which might make the cabinet operate better, a reduction in evaporator surface, or use of an inadequate or undesirable type of evaporator. Such compromises may affect one or more conditions such as freezing rate of foods, the amount which can be frozen satisfactorily at one time, the power consumption, and the maintenance of proper and uniform storage temperature. There is little question that proper performance takes precedence over price and only compromises resulting from technical advancement or efficient manufacture should be considered to deliver a cabinet at low cost to the purchaser. If the future cabinets are to give proper and satisfactory results, the engineering which goes into them must be based on sound thought and scientific facts, remembering that the cabinets must be designed for the careless as well as the careful user; also remembering that any two products may not be similarly affected under similar conditions.

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A Farm Motor Conservation Program

By E. S. Shepardson

JUNIOR MEMBER A.S.A.E.

FOR the past two summers (1941 and 1942) Cornell University's "wattmobile", an electrical demonstration truck and trailer, has been traveling throughout New York state in co-operation with the electric power companies of the state. The demonstration dealt mainly with the adequacy of the farm electrical system and the care of small electrical appliances.

The electric motor situation was beginning to get critical and need for a winter program was apparent. Reports were being received regularly of motors on milking machines, milk coolers and water systems "burning out", or failing in other ways. This probably was nothing out of the ordinary, but farmers could not find new motors available nor could they get the old ones repaired without a great deal of delay, if at all. There were no new motors for farmers and the few remaining repair shops were two and three months behind.

To help plan a program and coordinate efforts for the care of farm electrical equipment, the rural service men of the electric utility companies were invited to Cornell. As a result of this meeting, the fifteen district agricultural engineers working with the state emergency farm machinery program were given special training in the care of motors and overload protection devices for farm motors so that they might discuss cleaning, lubrication, and motor protection at their farm machinery meetings. Many rural service men discussed the care of motors at the meetings held by the district agricultural engineers. Due to the shortages of man power at the college, several of the district agricultural engineers and rural service men held their own electric motor meetings as time went on.

At first it was thought that the only kind of meetings that could be held would be those of a discussion or demonstration type. An electric motor "clinic" had never been held, and there was considerable doubt as to whether it would work out, as it was felt that the men would be reluctant to disconnect and bring motors in to a clinic. Of course it is a well-known fact that farmers actually like to get their "hands on" any piece of mechanical equipment that they are learning about.

A few experimental "clinics" were held and the results were surprising to all concerned. Farmers did bring in motors and from the very first clinic the program can be called successful. Once again the farmer had been underestimated!

During a four-months period 220 meetings were held in 34 of the 54 agricultural counties with a total attendance of 3,310. To these meetings 936 motors were brought in, cleaned, and overhauled by the farmers under the supervision of an agricultural engineer.

Three types of meetings were offered: the one-hour discussion or demonstration designed to be used on the program of some other meeting such as a dairy or milking machine meeting; the one-half day meeting, and the all-day clinic. No major overhaul work was attempted at these meetings. The clinic proved to be the most successful and also the most popular of the three.

The clinic was usually scheduled to start at 10:00 a. m. and last until all the motors had been cleaned and overhauled. In some cases this was about 7:00 p. m.; however, the clinic was usually over between 4:00 and 5:00 p. m. As the farmers came in with their motors, they were given instructions on taking them apart and cleaning them. The motors were carefully examined to determine if major repairs were necessary. There was usually a lathe not too far distant so the commutators could be turned if necessary. Bearings and rewinding jobs had to take their turn through the repair shops which were in many cases a great distance from the farmer.

After lunch a demonstration was given. The demonstration covered the causes of low voltage, its effect on the motor, and how to prevent this condition; overload protection devices, their use, necessity, and installation; cleaning; lubrication; brush and commutator care; belt tightness and alignment. Types of motors and their use and wiring connections were also discussed. After this the farmers finished working on their motors.

In many cases delayed action fuses were carried to be sold to those who could not get them elsewhere.

The one-half day meeting consisted of the demonstration mentioned above and farmers were invited to bring motors for checking over and diagnosing of troubles. This type of meeting, however, many times developed into a clinic and often an evening meeting lasted until midnight.

You may be interested in the condition of some of the motors brought into these clinics. To start with, practically every motor brought in needed a good cleaning. One split-phase motor used for odd jobs around the shop was in such condition that it seemed impossible for it to run at all, but the farmer had used it only that morning. The bearing on the pully end was completely worn away. The stator and rotor were smeared with a grease much like axle grease. Needless to say, the rotor was riding fully on the stator. This motor was still running! Of course, after the grease was cleaned from the motor the bare metal of the rotor rubbed on the stator and the motor would not operate. The owner was somewhat put out for a moment and thought that the grease should not have been removed.

Many motors had all air passages completely closed by dust and dirt with a liberal amount of oil to hold it in place. Motors from milking machines, often installed in the stable, are subjected to a great deal of dust and the air passages become clogged in a relatively short time. One such motor when taken apart for cleaning at the clinic disclosed two dead mice packed in with the dust and dirt. The owner said that this motor "had been getting hot enough so that he could smell it lately."

Another motor brought in was said to be burned out. The dealer had sold the farmer a new pump motor two years before because he had said it was no good. The farmer didn't let the dealer have the old motor this time. At the clinic the commutator of the so-called "no good" motor was polished with sandpaper and the brushes were freed in the brush holders. The motor ran as good as new again, much to the farmer's surprise.

There is a genuine lack of knowledge in regard to the electrical system and equipment. "Split-phase", "capacitor", and "repulsion induction" are meaningless terms to the farmer. Consequently, these terms are not used unless an explanation accompanies each. "The milking machine motor", "the pump motor", or "that motor with the can on top" are more common terms to him. Many a split-phase motor has been burned out when substituted for a pump motor. A motor is a motor to the farmer, and as long as it is somewhere near the right size he thinks it should work on any piece of equipment. Electricity is merely something that you can turn on and off for lights, motors, etc. Wire sizes and distances are not even thought of. A fuse is just a gadget that costs a nickel. Just put in one big enough so that it doesn't blow out! Never mind burning out the motor! Altogether too many motors are installed with no thought of insuring good voltage, and overload protection is hardly ever thought of. (It is fortunate that in recent years many manufacturers have incorporated overload protection in many of their motors or equipment.)

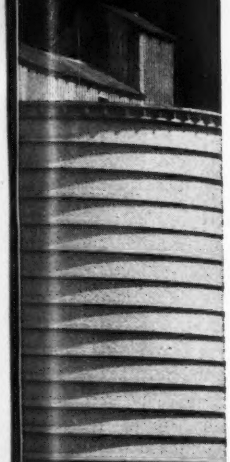
The farmer has decided that if the motor will last for two to five years that it is time to get a new one. He seldom goes near the motor as long as it keeps running because no one has taken the trouble to tell him how to care for it, and it is a little late to start finding out how to care for it after it has burned out. It is sometimes rather difficult to make a man understand that he should give the motor periodic care until after he has had the misfortune of burning one out at a time when he has difficulty in getting it in operation again.

The electrical system and motors are understood by the farmer about the same as water systems and gas engines were understood twenty years ago, or, in other words, he knows very little about them. Most farmers have a keen desire to learn about the electrical system and its equipment. They want (Continued on page 358)

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Lafayette, Ind., June, 1943. A contribution of the Rural Electric Division.

E. S. SHEPARDSON is extension instructor in agricultural engineering, Cornell University.

in Lumber



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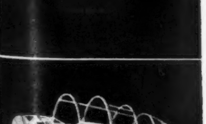

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NEWS SECTION

A.S.A.E. Meetings Calendar

December 6 to 8—Fall meeting, La Salle Hotel, Chicago, Illinois.

June 19 to 21—Annual Meeting, Hotel Schroeder, Milwaukee, Wis.

A. S. A. E. Fall Meeting

THE program of the Fall Meeting of the American Society of Agricultural Engineers, to be held at the LaSalle Hotel, Chicago, December 6, 7, and 8, promises to be another outstanding engineering contribution to the solution of wartime agricultural problems. The setting up of higher farm production goals in 1944 constitutes a real challenge to agricultural engineers, especially in the face of equipment, materials, and labor shortages. While marked progress has been made in the past year to relieve these shortages, there will just not be enough to supply all the needs of agriculture as well as those of the armed forces.

The program for the meeting is being sponsored by the four technical divisions of the Society — Power and Machinery, Rural Electric, Farm Structures, and Soil and Water — and the chairman of each division is arranging a program for two to three half-day periods, not counting joint programs. Probably one half-day will be devoted to a general program of interest to all four technical groups. It is planned to schedule not more than two concurrent divisions for any one period.

The two evenings between the three days of the meeting will be reserved for informal meetings, preferably of technical committees and other groups. This will also give more opportunity for individuals attending the meeting to make desired contacts. The day following the meeting —Thursday, December 9 — will feature a series of non-technical group meetings, including Meetings Committee, War Activities Committee, etc., which usually can be held more satisfactorily after than during or prior to a Society meeting.

The program of papers and speakers in complete form will shortly be released. Copies of the program and other information about the meeting may be obtained from Society headquarters at St. Joseph, Michigan.

New York War Conference

THE "Second Wartime Conference" of the North Atlantic Section of the American Society of Agricultural Engineers was held at New York City, September 27 and 28. Contrary to expectations, the attendance at the meeting was the largest of record in the history of the Section, the total registered attendance being 155, more than half of which were members of the Society.

Program subjects and speakers had been well selected, and all sessions of the meeting, from beginning to end, were well attended.

At the business session of the Section, R. J. Bugbee, agricultural engineer, Central Vermont Public Service Corp. was reelected secretary-treasurer of the Section for the ensuing year. A. W. Clyde, professor of agricultural engineering, Pennsylvania State College, was elected vice-chairman of the Section, and R. G. Harvey, manager of rural service, Central New York Power Corp. was elected chairman — and thereby became custodian of the famous Section gavel, which has an interesting history.

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Soybean Storage Studies

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Construction was started October 1 on about 70 bins to be used in the studies which will serve as a basis for recommendations to prevent or reduce storage losses. The Commodity Credit Corporation will loan about 100,000 bushels of beans for use in the study. The agricultural engineering problems to be studied include comparisons of wood and steel bins, methods of insect control, best size for bins, moisture movement in size of bins, value of natural ventilation, artificial drying or moisture reduction, designs for meet-

NEWS SECTION

A.S.A.E. Meetings Calendar

December 6 to 8—Fall meeting, La Salle Hotel, Chicago, Illinois.

June 19 to 21—Annual Meeting, Hotel Schroeder, Milwaukee, Wis.

A. S. A. E. Fall Meeting

THE program of the Fall Meeting of the American Society of Agricultural Engineers, to be held at the LaSalle Hotel, Chicago, December 6, 7, and 8, promises to be another outstanding engineering contribution to the solution of wartime agricultural problems. The setting up of higher farm production goals in 1944 constitutes a real challenge to agricultural engineers, especially in the face of equipment, materials, and labor shortages. While marked progress has been made in the past year to relieve these shortages, there will just not be enough to supply all the needs of agriculture as well as those of the armed forces.

The program for the meeting is being sponsored by the four technical divisions of the Society — Power and Machinery, Rural Electric, Farm Structures, and Soil and Water — and the chairman of each division is arranging a program for two to three half-day periods, not counting joint programs. Probably one half-day will be devoted to a general program of interest to all four technical groups. It is planned to schedule not more than two concurrent divisions for any one period.

The two evenings between the three days of the meeting will be reserved for informal meetings, preferably of technical committees and other groups. This will also give more opportunity for individuals attending the meeting to make desired contacts. The day following the meeting —Thursday, December 9 — will feature a series of non-technical group meetings, including Meetings Committee, War Activities Committee, etc., which usually can be held more satisfactorily after than during or prior to a Society meeting.

The program of papers and speakers in complete form will shortly be released. Copies of the program and other information about the meeting may be obtained from Society headquarters at St. Joseph, Michigan.

New York War Conference

THE "Second Wartime Conference" of the North Atlantic Section of the American Society of Agricultural Engineers was held at New York City, September 27 and 28. Contrary to expectations, the attendance at the meeting was the largest of record in the history of the Section, the total registered attendance being 155, more than half of which were members of the Society.

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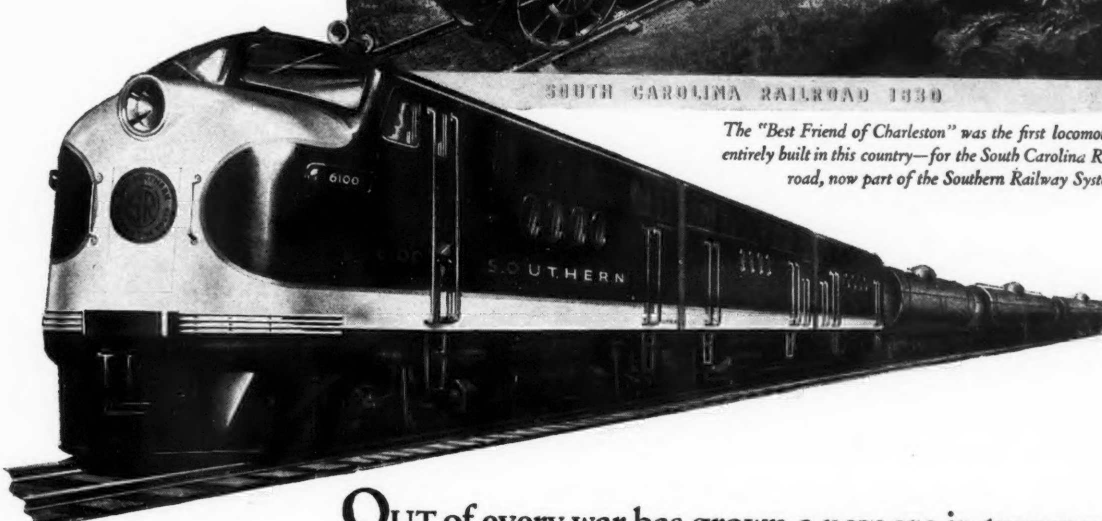
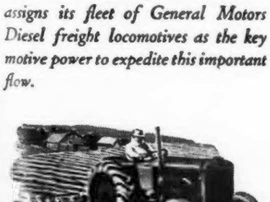
THERE'S SOMETHING NEW IN THE PICTURE

The "Best Friend of Charleston" was the first locomotive entirely built in this country—for the South Carolina Railroad, now part of the Southern Railway System.



Daily movement of a staggering quantity of oil from New Orleans to the Eastern States is the No. 1 war job of the Southern Railway. The Southern assigns its fleet of General Motors Diesel freight locomotives as the key motive power to expedite this important flow.



There will be something new in the farm and industrial pictures too. For there will be GM Diesels ready to serve wherever America needs power.

OUT of every war has grown a new era in transportation. This one is no exception. The pattern of that new era had been set, even before this war, by the General Motors Diesel Locomotive. And its Leadership in the Peace to come is forecast in the way this locomotive is today meeting the challenges of war.

GM
GENERAL MOTORS
DIESEL POWER

LOCOMOTIVES.....................ELECTRO-MOTIVE DIVISION, La Grange, Ill.

ENGINES..150 to 2000 H.P...CLEVELAND DIESEL ENGINE DIVISION, Cleveland, Ohio

ENGINES.....15 to 250 H.P......DETROIT DIESEL ENGINE DIVISION, Detroit, Mich.

ing strength requirements, methods of maintaining low moisture conditions, effect of storage on germination, fat acidity and market grade, and recommended designs for farm storage bins.

Leo E. Holman, agricultural engineer, BPISAE, is being transferred from Ames, Iowa, to represent the USDA.

Other agricultural engineers to be associated with this project are Wallace Ashby, chief of the farm structures section, BPISAE; and W. V. Hukill, senior agricultural engineer, BPISAE, who has recently been transferred from Wenatchee, Washington to Ames, Iowa.

Although the investigation involves the use of more than $200,000.00 worth of bins, soybeans, and equipment, much of the cost will be covered by the sale of beans at the end of each year's tests so that it is expected that the net cost will be very low. Recommendations resulting from the study that bring about even a slight reduction in storage losses will be worth millions of dollars to producers.

A New Bibliography of Agriculture

TO PROVIDE full and prompt coverage of the information in the scientific, technical, and economic material received in the Library of the U. S. Department of Agriculture, Washington, D. C. — which is the world's greatest repository of information about agriculture, food, and related subjects — the Library last month initiated a new service in its monthly "Bibliography of Agriculture." Intensified war programs of the USDA and of the other war agencies, both civil and military, have greatly increased the need for up-to-the-minute information on varied subjects.

The Bibliography will attempt to organize all the information in current agricultural literature, regardless of the form of the publication or the language in which it was originally produced. The size of this undertaking is indicated by the fact that the first issue contains more than 4,000 titles of books and articles, and the total number of articles listed each year will probably exceed 50,000. In the past, all the abstracting and indexing journals together covered only a small fraction of the 12,000 periodical publications received currently in the Library. The Bibliography of Agriculture is intended to make the subject matter of all of these periodical publications, as well as of books and pamphlets, available within a month of the time they are received. This new periodical replaces several mimeographed lists which formerly covered parts of the field. Each monthly issue will contain a detailed table of contents and full author and subject indexes.

Free distribution is limited to federal, state, and other public agencies. However, subscriptions may be placed with the Superintendent of Documents, Washington, D. C., for $3.75 a year. Single numbers sell for 35 cents.

Personals of A.S.A.E. Members

D. A. Milligan was recently appointed director of research for Harry Ferguson, Inc., after a service of fourteen years as agricultural engineer, equipment sales manager, and manager of the job order division for Cleveland Tractor Co. Mr. Milligan holds a master's degree from the University of Illinois, and following graduation spent eight years in the educational field, serving on the faculties of the Northwest School of the University of Minnesota at Crookston and of the University of Illinois. He also spent two years with the U. S. Department of Agriculture as service overseer in charge of maintenance and reconditioning of all agricultural equipment used in the corn borer control campaign. He will continue to act as a consultant to the farm machinery division of WPB. In 1942-43 Mr. Milligan served as chairman of the A.S.A.E. Power and Machinery Division.

H. E. Pinches was recently appointed as director of farm practices with Harry Ferguson, Inc. For nine years he has been head of the agricultural engineering department at the University of Connecticut, prior to which he was at one time associated with Thomas D. Campbell at Hardin, Montana, and later with Hickman Price of Amarillo, Texas, in the operation of large scale wheat farms. For a time he was also connected with the Civilian Conservation Corps, where he directed soil erosion control work. In his new position Mr. Pinches will devote his time to the study of methods and equipment whereby farmers in all sections of the country can reduce production costs.

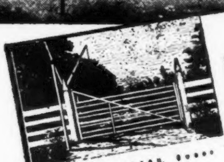
S. A. Anderson is now general manager of the Indiana Statewide Rural Electric Cooperative, Inc., with headquarters in Indianapolis, having resigned a few months ago as associate in agricultural engineering at Purdue University.

Gustav H. Bliesner has recently been appointed to the staff of the department of physics at Iowa State College as an instructor to teach engineering physics to army trainees. More recently he was agricultural engineer for the Bonneville Power Administration, U. S. Department of the Interior.

BURTON LANE FARM

Buildings and Equipment by JAMESWAY

The photograph above shows the exterior of one of the Jamesway equipped barns at Burton Lane Farm in Lake Forest, Illinois.



BURTON LANE FARM

Registered Guernseys

James Manufacturing Company
Ft. Atkinson, Wisconsin

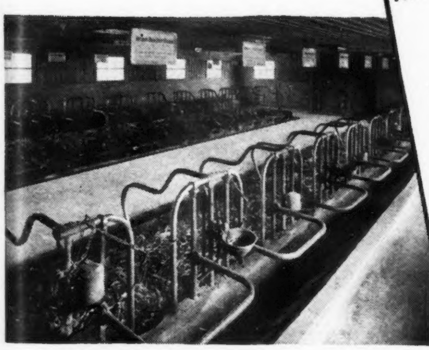
Gentlemen:-

We believe you will be interested in the splendid record established last year by our registered Guernsey herd which was housed in buildings and equipment which you furnished. They averaged 510.8 butter fat per head for this period and we feel that Jamesway equipment helped materially while establishing this splendid record.

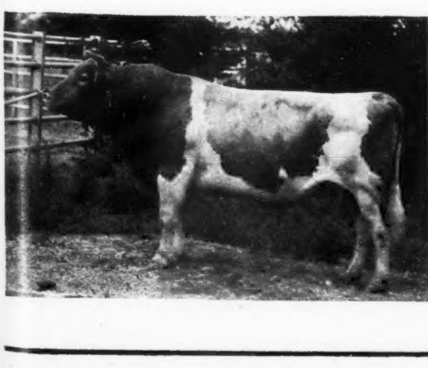
Everyone knows that cow comfort is most important for high production and your barns and efficient interior equipment have helped immeasurably in maintaining this high production record.

Yours very truly,
BURTON LANE FARM

Owner



Photograph showing an interior room equipped with roomy Jamesway tie stalls.



Our senior proved herd sire, Green Meads Sargon 211402, sire, Langwater King of the Meads 196129; dam, Green Meads Thelma 349034 — has many outstanding daughters in our herd.

When you plan to build, remodel or equip any type of farm service building, take advantage of Jamesway help.

JAMES MFG. CO., Dept. A - 1043.
Ft. Atkinson, Wis. Elmira, N. Y. Oakland, Calif.

EQUIPMENT & HOUSING
Jamesway
MORE MILK·EGGS·MEAT

Herman J. Finkel was recently appointed assistant agricultural engineer, U. S. Soil Conservation Service, and is located at Canastota, New York, where he is engaged in an erosion control program for the uplands of Madison County and in the drainage of extensive muck lands in that area.

John H. Hudson is again associated with the U. S. Soil Conservation Service and is located at Appling, Georgia, having been recently discharged from the Army on account of a physical ailment.

Mack M. Jones, professor of agricultural engineering, University of Missouri, is one of the authors of Bulletin 475, entitled "Corn Tillage Studies on Rolling Putnam Silt Loam," recently issued.

M. S. Klinck was recently appointed to take charge of agricultural engineering work at the University of Connecticut, Storrs, succeeding H. E. Pinches. Mr. Klinck was previously director of the division of agriculture of Hampton Institute.

W. C. Krueger, extension agricultural engineer, Rutgers University, is author of Circular 463, entitled "Food Preservation by Drying," recently issued.

L. F. Larsen has accepted appointment as extension agricultural engineer at the University of Nebraska. He was previously assistant professor of agricultural engineering at the South Dakota State College.

W. L. Powers, head, department of soils, Oregon State College, is on leave of absense until March and is serving as consultant on irrigation and soils to Venezuela Ministry of Public Works.

W. J. Promersberger, assistant agricultural engineer, North Dakota Agricultural Experiment Station, is author of Bulletin 325, entitled "Insulating Farm Buildings," just issued.

R. O. Schlegelmilch has been promoted from assistant radio engineer to associate radio engineer and is in charge of all engineering work for the U. S. Army Signal Corps at Research Enterprises, Ltd., in the province of Ontario, Canada.

Clarence E. Stevens, Jr., formerly instructor in agricultural mechanics at the University of Delaware, now holds the position of agricultural engineer with J. J. White, Inc., producers of cranberries and blueberries. His work includes supervision and operation and repair of machinery as well as of plumbing, electrical work, surveying, and building construction.

Harry Stierli, until recently junior mechanical engineer in the Western Regional Research Laboratory of the USDA Bureau of Agricultural and Industrial Chemistry, was granted a commission (lieutenant) by the U. S. Public Health Service as assistant engineer in the Reserve Corps. His assignment is with the Malaria Control in War Areas division, with headquarters at Atlanta, Georgia. At present he is assigned to dog fly control in northwestern Florida.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

J. M. Culpepper, assistant county agent, Alabama Extension Service. (Mail) Box 311, Haynesville, Ala.

Irby S. Exley, Infantry, USA. (Mail) RR No. 2, Clyo, Ga.

Ladd Haystead, agricultural consultant, Time, Inc. (Mail) RR No. 1, Wallkill, N. Y.

Elwyn S. Holmes, research assistant, agricultural engineering department, A. & M. College of Texas, College Station, Tex.

Robert R. Roth, engineering department, Goodyear Aircraft, Akron, Ohio. (Mail) Y.M.C.A.

Paul F. Swanson, poultry breeder and hatchery, Rail Tree Farm, Chelmsford, Mass.

William C. Wenner, Jr., associate engineer, field operations division, U. S. Rural Electrification Administration. (Mail) RR No. 4, Gettysburg, Pa.

Henry B. Winter, superintendent of construction, R. E. Rippe, General Contractor. (Mail) Carter Hotel, Hastings, Nebr.

TRANSFER OF GRADE

Floyd W. Anderson, machine designer, David Bradley Mfg. Works. (Mail) 502 River St. (Sunnyside), Kankakee, Ill. (Junior Member to Member).

Laurence L. Koontz, division rural supervisor, Appalachian Electric Power Co. (Mail) Bluefield, W. Va. (Junior Member to Member)

J. P. Schaenzer, senior electro-agricultural engineer, Rural Electrification Administration, U. S. Department of Agriculture. (Mail) 7108 Dale Ave., Richmond Heights 17, Mo. (Member to Fellow)

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers at the address indicated.

PLOWING TERRACED LAND, *E. G. Johnson.* U. S. Dept. Agr. (Washington) Leaflet 214 (1942). The following recommendations are briefly discussed and illustrated by photographs: Plow on the contour, repair terraces before plowing, vary method of plowing the area between terraces, and plant and cultivate parallel to terraces.

VENTILATION OF ANIMAL SHELTERS, *J. C. Wooley.* Missouri Ag. Exp. Sta. (Columbia) Cir. 219 (1942). Simple and inexpensive natural draft-insulated ventilating flues and fresh air inlets of several forms are briefly described and are shown in diagrammatic drawings. Mechanical draft ventilation is also mentioned, but information on this type of ventilation is confined to a table of fan sizes and speeds to provide adequate ventilation for specific numbers of cows, horses, hogs, or hens.

TECHNIQUE OF DETERMINING SHEARING STRENGTH OF SOILS: Progress report of a special committee of the soil mechanics and foundations division on the technique of soil tests, *B. K. Hough, Jr.* Amer. Soc. Civ. Engin. (New York) Proc., 68 (1942). No. 2 The committee reports conclusions drawn in part from a questionnaire requesting from testing laboratories (1) a detailed description of the equipment used for shear testing, (2) an outline of testing procedure including sample preparation, and (3) an explanation of methods of interpreting or applying test data to practical problems. In part, the conclusions are that the double-shear device seems better suited to empirical comparisons of different soil types than to determination of the actual shearing strength of soils. Choice between the direct-shear and the triaxial-shear testing equipment in any practical work depends on the nature of the individual problem. For research, the triaxial equipment appears to be more satisfactory, an exception being the stabilometer, which has certain construction features which make it more suitable for empirical tests than for research. No testing equipment can be considered entirely satisfactory, except for empirical tests, until the state of stress that it produces in the specimen is definitely known. Testing procedure must be varied to fit each problem. Efforts to determine "the" shearing strength of a given soil will be discontinued. The committee believes that in some cases in actual practice the necessary data on soil characteristics may be assumed by an experienced soils engineer without any tests at all, at least for preliminary design purposes, provided he has a clear conception of stress conditions in the prototype. *(Continued on following page)*

A Farm Motor Conservation Program

(Continued from page 348)

the mystery taken out of it and are just waiting for someone to explain what voltage and amperes mean. They are amazed when told that the length and size of wires affects the voltage which may in turn affect their motor to the extent of burning it out. They are glad to find out how to fuse and protect their wiring systems correctly, and especially their motors.

Here is a story of a farmer and his motor. The farmer brought his water pump motor in to a local repair shop and requested that it be overhauled and put into first-class condition. The repairman looked the motor over, found that it was in excellent condition, and that it was equipped with some kind of overload device. The owner said he had used the motor for 18 years on his water system. The repairman remarked to the farmer that he must have taken good care of his motor all these years. The farmer, however, said that he didn't know anything about motors and so hadn't taken good care of it. He said, "Once a year I take it off the end plates, brush it out, and wash the old oil out of the bearings and recoil it. I also polish the commutator with some sandpaper and put in new brushes. I don't know whether I should do these things or not, but I have been doing them anyway." The repairman had a hard time convincing the farmer that his motor was in excellent condition and needed no repair work. He isn't sure yet that the farmer believed him.

This is the kind of story all farmers ought to be able to tell about their motors.

Is an annual cleaning and overhauling of a motor too much to ask when the life of a farm motor can be lengthened to this extent? Electric motor clinics seem to be a way of starting a program of motor conservation.

Agricultural Engineering Digest *(Continued)*

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE SOUTH DAKOTA STATION. South Dakota Ag. Exp. Sta. (Bismarck) Rpt., 1941. R. L. Patty reports on the comparative costs and the condition after 16 years' service of galvanized and painted steel fence posts, L. F. Larsen and Patty on conversion of horse machinery for tractor farming and on tests of new materials and methods for farm building floors, Patty and H. H. DeLong on continued experiments in the use of rammed earth walls, DeLong and Larsen on prevention of mechanical injury to barley, and Patty and W. E. Poley on work on a rammed earth poultry house.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE WASHINGTON STATION. (Partly coop. USDA). Washington Ag. Exp. Sta. (Pullman) Bul. 410 (1941). L. J. Smith reports upon apple juicers, lighting of flowers, pig and lamb brooding, all-electric greenhouse, dressed poultry cooling, poultry lighting studies, and light trap investigations for codling moth control.

A PROGRESS REPORT ON THE INVESTIGATION OF THE VARIOUS USES OF ELECTRICITY ON THE FARMS OF WASHINGTON FOR THE YEAR 1941. Wash. Com. Relat. Elect. Agr. (Pullman), Annual Rpt. 17 (1941). This report deals with current results of various investigations as follows: Electric Light for Egg Production, by J. Roberts and J. S. Carver (Wash. Ag. Exp. Sta.); Poultry Air-Conditioning, by J. S. Kincaid and J. Roberts; A Comparison of the Wet and Dry Cooling of Dressed Poultry, by J. Roberts and E. I. Robertson (Wash. Sta.); Water Warming for Poultry, by J. S. Carver and J. Roberts; Evaporative Egg Room Cooler and Humidifier, by W. A. Luce and J. Roberts; The Fundamental Requirements of Poultry Brooding, by J. Roberts and J. S. Carver; Studies of the RS-4 Lamp, by J. S. Carver, Rhian, and J. Roberts; The All-Electric Greenhouse and Electric Light for Carnations both by J. Roberts and S. E. Wadsworth; Farm Refrigeration; Germicidal Lights for Meat Storage, by Ensminger, J. A. McIntosh, C. C. Prouty, J. Roberts, and J. Sotola; Livestock Tank Heaters; Electric Pig and Lamb Brooders; Milk Houses, by H. A. Bendixen, J. Roberts, and L. J. Smith; Milk Cooling Survey, by H. A. Bendixen and J. Roberts; and Poultry House Blackout Effects Poultry Lighting Schedules, by J. S. Carver.

PRESERVATIVE TREATMENTS OF FENCE POSTS: 1941 PROGRESS REPORT ON THE POST FARM, *T. J. Starker*. Oreg. Engin. Exp. Sta. (Corvallis) Bul. 9-C (1941). This is the 1941 progress report on an endurance test set up in 1927.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE SOUTH CAROLINA STATION. South Carolina Ag. Exp. Sta. (Clemson) Rpt. 1941. G. H. Dunkelberg, G. B. Nutt, H. T. Polk, and A. R. Reed recorded data showing that corrosion of the fencing materials is more severe on the posts treated with copper sulfate than on those treated with zinc chloride, and more severe on posts treated with zinc chloride than on untreated posts, corrosion more severe on the staples than on the wire and more severe on polished staples than on the coated staples. While none of the treated posts showed insect damage, the untreated posts showed moderate to severe damage. J. B. Edmond and Dunkelberg report on electricity in sweetpotato plant production, and O. B. Garrison on flue-heated hotbeds for sweetpotatoes.

New Literature

"MUNICIPAL AND RURAL SANITATION," *by* Victor M. Ehlers, chief sanitary engineer, State Health Department of Texas, and Ernest W. Steel, professor and municipal and sanitary engineering, A. & M. College of Texas. Cloth, 6x9 inches, 450 pages, 132 illustrations. $4.00. McGraw-Hill Book Co., Inc., New York and London.

This is the third edition of this book which was published originally in 1927, the revision being necessitated by further advances in recent years in the practice of sanitation. The chapter on milk sanitation has been revised particularly in the treatment of pasteurization. A chapter on food sanitation has also been extensively revised, and new material has been added to chapters on mosquito control, refuse disposal, ventilation and air conditioning, industrial hygiene, and housing. While the book aims to cover the general field of sanitation, several chapters deal with phases of the subject of special interest to agricultural engineers, including the following: protection of water supplies, mosquito and fly control, rodent control, milk sanitation, food sanitation, plumbing, ventilation and air conditioning, light, housing, and disinfection.

PROFESSIONAL DIRECTORY

Consulting Engineering Work In Farm Structures Field
Also Sales Engineering for Selected Manufacturers

George R. Shier, A. E.

Member A.S.A.E. Associated with Howard S. Sterner Company, Consulting Structural Engineers, 30 East Broad Street, Columbus, Ohio

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of \$1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

ENGINEERS wanted by large manufacturer of pumping and other farm equipment, which carries an "essential" rating. Married men free from draft call preferred. Applications must be in writing with complete statement of qualifications and experience. Include photo. State salary expected. PO-145

FARM STRUCTURAL EQUIPMENT ENGINEER with aggressive, pleasing personality wanted to assist in the design, development, and manufacture of farm supplies and equipment in an essential industry. Farm structural equipment engineering training with some business experience in the farm supply field desirable. Submit snapshot with complete record covering education and experience. PO-144

AGRICULTURAL ENGINEERS wanted. A large farm implement manufacturer requires the immediate services of several experienced agricultural engineers. Excellent opportunities for the right men. Send photograph with complete history of past experience, references, and expected salary. PO-143

RESEARCH ENGINEER in electroagriculture wanted at The Pennsylvania State College, Department of Agricultural Engineering, State College, preferably a young graduate engineer vitally interested in research where engineering fundamentals are applied to problems in agriculture. The program includes research in freezing, cooling, and heating; illumination as applied to biological, physiological, and bacteriological studies; dehydration; use of power, as well as electronics.

RESEARCH ENGINEER wanted for design and development of agricultural machinery and equipment for the Southeast. Salary up to \$3,000, depending on qualifications. Persons interested are requested to write giving full particulars regarding training, experience, and other pertinent information. PO-141.

POSITIONS WANTED

AGRICULTURAL ENGINEER with B. S. in both agricultural and mechanical engineering from midwestern university. Some graduate work in engineering. Desires position in college teaching, research, or extension, or with private concern. Has had experience in soil conservation, farm machinery and equipment, farm structures, and rural electrification. At present employed as a state extension agricultural engineer. Farm reared. Married. Age 38. Good reason for desiring a change of position. References and professional record available upon request. PW-357

AGRICULTURAL MACHINERY BLOCKMAN and collector with three years in agricultural engineering work at Kansas State College, ten years' service with largest manufacturer of farm equipment, two years teaching in national defense training, and one year with farm machinery division of WPB, desires position in industry or in any branch of agricultural engineering, farm management, or farm machinery design. Age 40, health excellent, no defects or bad habits, married, rural background. Complete credentials furnished upon request. Available October 16, 1943. PW-356

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